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WE SHALL FULFILL THE FIRST YEAR OF THE SEVEN-YEAR PLAN AHEAD OF TIME

AN APPEAL BY THE WORKERS AND TECHNICAL PERSONNEL OF THE S. ORDZHONIKIDZE "ZAPOROZHSTAL'" FACTORY TO ALL WORKERS OF THE IRON AND STEEL INDUSTRY IN OUR COUNTRY.

DEAR COMRADES:

The Twenty-first Congress of the Communist Party of the Soviet Union, which has just finished its work, made an appraisal of the enormous work accomplished by the Soviet people under the wise leadership of the Communist Party, and passed a magnificent program for the development of the national economy for 1959-1965; this program, when fulfilled, will enhance the might of our country and raise the Soviet people's standard of living even more.

The resolutions of the Twenty-first Congress of the Party mark the beginning of the glorious new period in the life of our great motherland — the period of the expansive building of the communist society.

In his speech to the Twenty-first Congress of the CPSU, Comrade N. S. Khrushchev pointed out that, after the resolutions of the Congress have been passed, each republic, territory, province and region; every works, factory, state farm, collective farm and scientific establishment should correctly define concrete tasks which have to be accomplished by the respective personnel in a given field with a view to an active participation in fulfilling and more than fulfilling a Seven-Year Plan.

We, workers, technical and administrative employees of the S. Ordzhonikidze "Zaporozhstal'" Factory, together with all Soviet people, with deep emotion, with a sense of pride and joy in the great Party of Lenin and our mighty motherland, accepted the Seven-Year Plan as our own cause and we are ready to contribute all our strength in the struggle to realize it.

We fully appreciate what important part is played by iron and steel industry in the successful completion of the Seven-Year Plan and the establishment of the material and technical basis of Communism. The Central Committee of the CPSU and the Soviet Government, with consistency and perseverance, are trying to ensure that the production of steel should stay ahead of other branches of the national economy since the rate of development of all branches of the national economy are directly dependent on the successful work of the iron and steel industry and on the rate of increase in steel output.

A successful completion of the Seven-Year Plan depends on the performance of each establishment and of every worker and, therefore, while unanimously and enthusiastically supporting the appeal of the Twenty-first Congress of the CPSU, we suggest that a Socialist Competition for the fulfillment of the Seven-Year Plan ahead of time with respect to steel output should be started.

The fulfillment of the Seven-Year Plan ahead of time can be accomplished if we, iron and steel workers, fulfill and more than fulfill the annual production plans. We know from the experience at our Works that there are the necessary industrial potentialities for fulfilling the Seven-Year Plan ahead of time at the establishments of the iron and steel industry.

In the course of the competition to mark the Twenty-first Congress of the CPSU a new form of Socialist Competition — the "Teams of Communist Labor" — came into being. The workers of the "Zaporozhstal'" were among the first who supported this patriotic initiative.

Having studied the planned figures for the development of the national economy of the USSR for 1959-1965 and having taken stock of our possibilities we workers and technical employees of the S. Ordzhonikidze "Zaporozhstal'" Metallurgical Factory have decided to fulfill the 1959 plan ahead of time and we undertake the following obligations:

1. To fulfill the production plan ahead of time and produce 20,000 tons of pig-iron, 35,000 of steel, 25,000 of rolled product, 2000 tons of tin-plate and 40,000 tons of sinter over and above the annual quota.

2. By means of a further modernization of equipment, the mechanization and automation of production processes and the introduction of advanced techniques to achieve the following:

— a mean daily output of 2485 tons of sinter from a single sinter machine of 500 m^2 area;

— a ratio of blast furnace volume to the daily output of 0.737 for furnace No. 3, 0.725 for furnace No. 4 and 0.716 for furnace No. 5, and a reduction in coke consumption to 665 kg per 1 ton of conversion pig iron.

— an annual output of steel of 225,000 per 185-ton open-hearth furnace and 310,000 tons per 370-ton open-hearth furnace.

3. To increase operating efficiency by 1% compared with the figure in the plan.

4. To attain a saving of at least 10 million rubles on account of an extra reduction in production costs.

5. To save at least 12 million rubles by adopting new suggestions and inventions in production processes.

6. To teach new trades and improve the qualifications of 4000 men.

7. In order to carry out the assumed obligations with respec to the increase in steel output and the reduction of its cost, the personnel of the Works intends to do the following:

—to modernize 5 sinter plants with a view to increasing their sinter area from 50 m^2 to 62.5 m^2 and to carry out their automation;

—to increase the volume of blast furnace No. 2 by 550 m^3 when repairing it, and, thus, to increase its output by 700 tons per day. To master the pig-iron production with the use of oxygen and natural gas and to increase the temperature of the blast to 1000 °C;

—to extend the application of oxygen in the open-hearth shop for the intensification of the open-hearth process and preliminary treatment of pig-iron in the mixer and in the ladles. To increase, in the course of repairs, the capacity of 185 ton open-hearth furnaces to 220 tons. The repair shops of the works should produce all-welded, light-weight, steel-pouring ladles, install a powerful baling press for an improved preparation of steel scrap and for speeding up the charging operations of open-hearth furnaces. To complete the transition of all open-hearth furnaces to evaporation cooling and to equip them with waste-heat boilers.

In the steel-rolling mills, to install and put into operation one group of soaking pits, to increase the speed of rolling and for this purpose to replace the motors of the main drives of the continuous thin sheet mill, to modernize the pickling lines, and to start work on introducing the production of cold-rolled strip in a coil. To carry out work with regard to a further automation of the steel-rolling mills.

We assure the Central Committee of the CPSU and the Soviet Government that we shall mobilize all our knowledge and strength in order to accomplish the accepted obligations with honor.

We appeal to all workers in the iron and steel industry to accept our challenge to join in the Socialist Competition for the fulfillment of the first-year target of the Seven-Year Plan ahead of time, for a full utilization of internal production reserves, for increasing the output of pig-iron, steel and rolled-product, for mastering the production of new steel grades and economic steel sections, for the adoption of new techniques and advanced experience, for the mechanization and automation of industrial processes, for an increase in operating efficiency, for an improvement in the steel quality and a reduction in its cost.

We shall mark 1959 — the first year of the Seven-Year Plan — with new successes in the fulfillment of the grandiose plan for the development of the national economy as outlined by the historic Twenty-first Congress of the Communist Party of the Soviet Union.

Discussed and passed by meetings of workers and technical personnel in teams and shops, and in the Party Economic Group at the S. Ordzhonikidze "Zaporozhstal'" Factory.

* * *

The Presidium of the Central Committee of the Trade Union of Iron and Steel Workers considered, on February 27, 1959, the appeal of workers and technical personnel of the "Zaporozhstal'" Factory and passed a resolution approving the patriotic initiative of the employees of the "Zaporozhstal'" Factory to organize a Socialist Competition for fulfilling the State Plan for 1959 — the first year of the Seven-Year Plan — ahead of time.

The Republic, Territorial, Provincial, Town and Factory Trade Union Committees jointly with the Ferrous-Metallurgy Departments of the National Economic Councils and the managements of iron and steel works have been instructed to give wide publicity to the appeal of the "Zaporozhstal'" Factory, to ensure that every worker, team, shift, shop and establishment joins the competition, to pay special attention to the best utilization of production capacities, and to give wide publicity to the progress of the competition for fulfilling the State Plan for 1959 ahead of schedule.

* * *

OPERATION OF THE BLAST FURNACE WITH SIZE-GRADED FLUXED SINTER

S. K. Trekalo, N. M. Yakubtsiner, and A. B. Shur

TSNIICHN*, LPI and Cherepovets Metallurgical Works

An article by V. E. Levchenko and K. A. Bovkun on the operation of the blast furnace with size-grade charge was published in Metallurgist No. 5, 1958, as a subject for discussion.

We publish herewith a reply to this article.

An extensive application of fluxed sinter, an increase in the pressure in the furnace top, an increase in blast temperature, the change to the production of low-manganese pig-iron and other technological improvements introduced at blast furnaces in the Soviet Union have resulted in a sharp reduction in coke consumption per ton of pig-iron. At factories where raw limestone has been completely eliminated from the charge of the blast furnace or its input reduced to a few kilograms per ton of pig-iron and where furnaces are operated at a high gas pressure and high blast temperature, coke consumption has fallen to 600 kg, or even less, per ton of pig iron.

It is essential to continue with the development of smelting methods which would permit a further reduction in coke consumption. One should not forget, however, that a reduction in coke consumption involves a reduction in the volume of that portion of the furnace charge which consists of the largest particles in the stock and results in lowering its permeability to gases.

The volume of blast furnaces in the Soviet Union is continuously being increased. This involves an increase in their working height and their cross-sectional dimensions. However, the increase in dimensions, while assisting in the increase of pig-iron output and in the reduction of coke consumption, presents some additional difficulties.

With the increase in the height of the stock, the path of the gases increases and the coke and sinter undergo more extensive comminution, hence, for the same type of raw materials, the resistance to the gas passage in high furnaces is higher than in low ones.

With the increase in the cross-sectional dimensions of the furnace there is an increase in the harmful effect of the segregation of various-sized materials which are charged into the furnace at the same time and consequently there is an increase in the nonuniformity of the physical state of the charge and of the gas flow over the cross-section of the furnace.

It is obvious from the foregoing that a further development of the technology of the blast-furnace process and the design of blast furnaces necessitates an improvement in the gas permeability of the charge in order to prevent a fall in the rate of the blast-furnace process. One can increase the gas permeability by means of reducing the percentage weight of slag and improving the physical properties of the raw materials and fuel.

Lowering the amount of slag plays an important part in the reduction of coke consumption and in the increase of the gas permeability of the charge in the zone of slag formation and should always be employed whenever the circumstances and the process conditions permit. However, even if the amount of slag is low, the operating efficiency of the blast furnace may be unsatisfactory. Thus, for instance, blast furnaces in northern districts of the USA have a hearth diameter of 8.54 m and produce conversion pig-iron from rich ores at a slag yield of 425-475 kg per ton of pig-iron, but without the use of fluxed sinter and at a relatively low temperature of the blast (440-530 °C) they have a high coke consumption (845-900 kg per ton of pig-iron) and a low daily output (from 1150 to 1260 tons). At the same time, operational experience at the Magnitogorsk Metallurgical Combine shows that with a rich charge (slag yield 470-550 kg per ton), a fully fluxed sinter, a high blast temperature (880-930 °C) and a gas pressure of 0.9-0.96 atmos, a low coke consumption (616-657 kg per ton) and a high output (a ratio of blast furnace working volume to daily output equal to 0.585-0.602) are attained. Operational experience at the Cherepovets Metallurgical Factory allows one to say that very good results with respect to coke consumption can be achieved even with a relatively large slag yield. At one of the blast furnaces at this Factory when it was operated with almost fully fluxed sinter, 1000 °C temperature blast, 1.5 atmos gas pressure at the furnace top and a slag yield of 670-690 kg per ton, the wet coke consumption amounted to 600-620 kg per ton of conversion pig-iron.

The ratio of the blast furnace working volume to the daily output at the Cherepovets Factory is somewhat inferior to that at the Magnitogorsk Combine and one of the causes is the higher slag yield.

It follows that in order to obtain good results in furnace operation it is very important to reduce the slag yield, but that is not all. It is necessary, at the same time, to apply other methods too and first of all to use

* Central Scientific Research Institute of Ferrous Metallurgy.

fluxed sinter which makes it possible to completely eliminate raw limestone from the blast-furnace charge. The examples quoted above show that V. E. Deryugin (Metallurgist No. 11, 1958) is not correct when he says that an improvement in operating efficiency in blast furnaces is obtained exclusively by means of enriching the ore with iron.

Fluxed sinter constitutes the main component of the iron-containing portion of the charge of blast furnaces in the USSR and, owing to a low coke consumption, occupies almost half the furnace volume. Therefore, size composition of the sinter becomes of great importance.

Below, we give the screen analysis of sinter taken from the bins of the blast furnace shops at some southern metallurgical factories in 1956-1957, in %:

Factory	Basicity of sinter	Fractions, mm +80	80–40	40–5	5–0
Krivoi Rog	1.2	15.8	6.7	56.7	20.8
Makeevka	1.01	7.7	5.0	61.2	26.1
Enakievo	0.87	14.6	11.9	61.0	12.5
	1.01	6.8	5.7	66.5	21.0

The Magnitogorsk Combine uses sinter of 1.4-1 46 basicity and of the following screen analysis:

Fractions, mm	+60	60–40	40–25	25–10	10–3	3–0
Screen analysis, %	13.6	6.2	7.0	45.6	17.8	9.8

The screen analysis of the Vysokogora Sinter Factory sinter of 1.0 basicity is:

Fractions, mm	+50	50–25	25–12	12–8	8–5	5–0
Screen analysis, %	10.4	10.0	30.7	17.7	12.0	19.2

At the blast furnaces of the Cherepovets Factory sinter of 1.15 basicity and of the following screen analysis is employed:

Fractions, mm	Screen analysis, %	Fractions, mm	Screen analysis, %
+100	1.1	40–25	20.3
100–80	1.3	25–10	42.7
80–60	2.0	10–5	14.3
60–40	9.4	5–0	8.9

It is seen from the data quoted above that with fluxed sinter the blast furnaces obtain a great deal of fines which have a harmful effect on the distribution of the charge materials and of the gas flow in the furnace and which increase the coke consumption and lower the rate of the smelting process. One can say with confidence that the elimination of fine particles – for instance 5 mm fraction – from fluxed sinter before it is charged into the blast furnace will make it possible to increase the output of the blast furnaces substantially and to reduce the coke consumption.

At the Cherepovets Factory, the sinter, after being discharged from the coolers, enters the vibrating screens where the 5-0 mm fraction is separated. However, on its way to the blast furnace the sinter is subjected to several transfers during which it is again size-reduced and, as a result, the content of large fractions in it decreases and small-size fractions appear again. As is seen from the table, the sinter sampled from the bins contains about 9% of 5-0 mm fraction, and although this amount is lower than at other works it nevertheless hinders a further intensification of the smelting process. The elimination of the fines from fluxed sinter constitutes an essential element in the preparation of raw materials but it does not exhaust all the possibilities of this method. A marked increase in the gas permeability of the charge can be achieved by separating the sinter according to particle size and charging the classes of different particle sizes separately into the furnace.

Academician M. A. Pavlov was the first to point out yet another important aspect of the advantageous effect of ore size-grading on furnace operation. The introduction of the ore in separate rounds of different-size fractions has a favorable effect on the distribution of the charge materials in the furnace top. When separate charging is employed, the ore of fine particle-size will not be distributed preferentially at the furnace wall but will reach the center as well and the large size ore, when charged separately, will be distributed more uniformly over the cross section of the shaft without accumulating in the center. A separate charging of materials which differ in particle size will eliminate the accumulation of the fines at the furnace walls and of the large particles at the center, it will make a heavier loading of the center of the shaft and a lighter loading of the periphery possible, and that, in turn, will improve the distribution of the gas flow over the cross section of the shaft. This is especially important in the operation of high blast furnaces of large cross section area. Hence, the proposal of the Gipromez to provide for the size separation of the charge at large blast furnaces now being designed is quite justified.

The best effect of the separation of the materials into classes according to particle size is obtained when there is a pronounced difference in size between the small and the large particles. If this difference is not large, the charge materials can be screened into a smaller number of fractions and thus the screening work is made easier.

Prof. I. A. Sokolov considered that a uniform resistance to the gas passage over the whole cross section of the furnace can be attained when the ratio of the size of the largest particle to that of the smallest is not more than 2:1, and for less stringent requirements – 4:1†.

† The optimum ratio between the sizes of the large and the small particles of fluxed sinter will be established by investigations on a special model of a blast furnace.

Having removed the fines of below 5 mm in size from the fluxed sinter, we obtain 5-80 mm particles. When such a sinter is separated into two fractions, for instance, 5-20 mm, 20-80 mm, the segregation of the particles according to size during the charging of the sinter into the furnace will be reduced to a minimum.

The advantages of the separation of ore according to particle size is confirmed by the operating statistics of some blast furnaces. At the Houston Iron and Steel Factroy (USA), a blast furnace with a hearth diameter of 7.7 meters operating on a lean charge, and giving a slag yield of slightly more than 1000 kg/ton of pig-iron, produced 1159 tons of pig-iron per 24 hours from raw unprepared ore at a coke consumption of 740 kg/ton. After the main bulk of the ore (80%) was separated into 0-9.5 mm and +9.5 mm classes and the classes were charged separately into the furnace, the output of the furnace increased by 71 tons per 24 hours (6.1%) and the coke consumption fell by 33 kg/ton (4.5%). Sintering the fines eliminated from the ore, and charging the remaining ore in separate fractions of 9.5-25 and +25 and the unscreened sinter separately, resulted in a further increase in the rate of the blast-furnace process and a corresponding increase in the blast-furnace output up to 1355 tons per 24 hours (10.2%). Coke consumption decreased by another 1%.

At the Appleby-Frodingham Factory in England, where a very lean charge is employed (1300 kg of slag and 2.62 tons of sinter per 1 ton of pig-iron), the fluxed sinter is screened into two classes. The screen analysis of the two classes is given below:

Fraction, mm	Class	
	large	small
+51	0	0
51-25.5	4.4	0
25.5-19	9.2	0.4
19-12.5	36.4	3.3
12.5-10	34.5	23.9
10-6	5.9	41.6
6-3	6.4	19.0
3-0	3.2	11.8

It is seen from the above table that the size separation was not adequate. Nevertheless, the separation made it possible to increase the blast rate by 10% and achieve a coke consumption of approximately 750 kg/ton of pig-iron when a sinter of low iron content was used.

The favorable effect of the size separation of fluxed sinter on the operation of the blast furnace is confirmed by the experience of the Domnarvet Factory in Sweden.

The desirability of changing to size-graded sinter in the Soviet Union is confirmed by an experimental heat carried out recently at the Cherepovets Metallurgical Factory‡. The vibrating screens designated for screening off the fines from the sinter after it has been discharged from the cooler were adapted for the separation of sinter into +25 and -25 mm classes. After the sinter was screened on the screen with a 25 mm opening between the bars, the +25 mm fraction in the large-size class constituted over 79% (mean value for the whole trial period). However, during transportation and unloading, the sinter tended to be reduced in size, so that the content of +25 mm fraction in the large-size class of sinter, taken from the blast-furnace bins fell, and the content of small-size particles (5-0 mm) increased. Thus, the screen analysis of the small-size class of the sinter was changed (see Table).

The experimental smelting carried out with size-graded sinter was continued for 20 days (from August 12-31, 1958). At the beginning of this smelting period, the furnace was operating on the charge consisting of 100% fluxed sinter of 1.15 basicity ($CaO:SiO_2$) and was producing low-manganese open-hearth pig-iron very economically. The coke consumption amounted to about 600 kg/ton of pig-iron, the ratio of the blast-furnace volume to the daily output was about 0.61 and the metal additions amounted to 20-40 kg/tons of pig-iron. The temperature of the hot blast was 1000 °C and the CO_2 content in the gas was about 16%.

The sinter was divided into two classes according to size and each class was charged into the furnace in separate rounds; the weight ratio of the large-size to the small-size sinter was 3:2.

When a change was made to operation with size-graded sinter, the method of charging was, initially, the same as before the experimental run: one round sinter-sinter-coke-coke and four rounds coke-sinter-sinter-coke. Three days later the system of charging was changed to a more economical one; two charges $sinter_s$-$sinter_s$-coke-coke and three rounds coke-$sinter_l$-$sinter_l$-coke**.

In spite of the smaller number of rounds charged according to coke-sinter-sinter-coke system during the trial period, the center of the furnace contained more sinter than before or after the trial period when there was a large number of "coke first" rounds.

The curves on the graph show that when size-graded sinter was introduced the gas flow over the cross section of the furnace became more uniform, this being a direct result of a less extensive segregation of sinter. Obviously, in the intermediate position of the shaft radius, i.e., in the annular space about 2 m wide (250-2000 mm from the lining) the charge became more permeable to the gas flow. Therefore, during the trial period, the carbon dioxide content within the annular space decreased while its total content in the blast-furnace gas increased. This redistribution of gases in the furnace when size-graded sinter was used constituted one of the factors which re-

‡ Besides the authors of this article, the following have taken part in the experimental work: L. Ya. Levin, I. A. Kuz'min, V. D. Kailov, G. F. Grigor'evykh, É. E. Gutman, V. M. Choleninov, V. L. Grinberg, V. A. Vanchikov, and V. N. Vitovskii.

** $Sinter_s$ denotes the sinter of the small-size class; $sinter_l$ denotes the sinter of the large-size class.

Screen Analysis of the Sinter Taken From the Bins of the Blast Furnace at the Cherepovets Metallurgical Factory

Sinter class	Fraction content (%), mm									
	+80	80-60	60-40	40-25	25-15	15-10	10-5	5-3	3-0	+25	-5
Large size (+25mm)	1.8	1.9	11.3	25.9	23.5	13.3	11.7	3.8	6.8	40.9	10.6
Small size (-22mm)	None	None	None	9.9	34.7	23.9	19.7	5.0	6.8	9.9	11.8

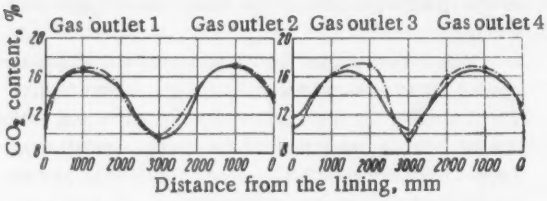


Diagram showing the distribution of CO_2 content along the radius of the furnace at the Cherepovets Factory:
_____size-graded sinter in the charge
-.-.-.-.-.-.-.ordinary sinter in the charge

sulted in a reduction of coke consumption during the trial period.

By using size-graded sinter it became possible to reduce the (dry) coke consumption at the Cherepovets Factory by 2.5%, i.e., from 596 to 581 kg/ton and to increase the output by 2.4%, in the course of 20 days.

When considering the qualitative results of the test, one should bear in mind that the furnace at which the experiments were carried out was showing the lowest coke consumption as compared with other blast furnaces in the Soviet Union. In a relatively short trial period it was not possible to establish operating conditions which would make use of all the advantages of size-graded sinter. Undoubtedly, when size-graded sinter is used permanently and the conditions for maintaining the required size classification of the sinter before it is charged into the skip are established, the operating statistics of the process will be improved. In order to satisfy the second condition, it is essential to arrange for the size separation of the sinter to be carried out as near as possible to the blast furnace.

The sinter is screened and the fines are removed from it most advantageously immediately after the sinter is discharged from the bins and before it is charged into the skip. In this way, the required size analysis of the sinter will be much better maintained since there will be a smaller number of loading and unloading operations after the size separation. Of course, there will be some size reduction during the remaining loading and unloading operations (on the way to the skip and the blast-furnace top). The sinter particles, however, will not be reduced very much, since from the whole bulk of the sinter the mechanically strongest portion of the sinter arrives in lumps at the bins. This is confirmed by the results of our experiments, according to which the mechanical strength of the sinter taken from the scale car is always higher than the mechanical strength of the sinter discharged from the sinter machine.

It follows from the results of the experimental heats, in which size-graded sinter was used, that for large furnaces it is necessary to separate sinter according to its particle size before it is charged into the skip and not at the sinter plant as is recommended by the Gipromez.

In our view, sinter of each size should be weighed by means of automatic scale hoppers similar to coke scale hoppers. Since it is practically impossible to obtain sinter in which a strict ratio between certain size-classes could be maintained, it is necessary to provide small intermediate storage capacities (for the two classes of sinter) between the location of screening and the hopper. The required weight of the sinter of one class only should be charged in each round without the idle skip run.

In the project, one should provide for a simple method of transferring the fines of both size classes from the stockhouse of the blast furnace to the charge yard of the sinter plant so that they can be used as cold returns to be introduced into the charge in the same way as other components of the sinter-plant charge.

* * *

INCREASING THE DURABILITY OF THE SWITCHES OF THE HOT-BLAST MAINS

I.A. Ivanov

Magnitogorsk Metallurgical Combine

In 1954, the mixer pipes at all the furnaces of the Magnitogorsk Metallurgical Combine were joined to the hot-blast mains behind the last stove away from the blast furnace. Since, at the same time, the straight hot-blast main was subjected to prolonged cooling by cold air, the service life of the refractory brick, in particular in the vicinity of the switches of the air main was affected. When the brickwork was damaged the furnace had to be stopped for the repair of the switches.

A suggestion to insert the mixing pipe between the first air-heating stove and the blast furnace, the mixing pipe being inclined toward the furnace, was not adopted because the cold air would not be mixed properly with the hot air over the small distance between the mixer and the bustle pipe. In order to obtain a better mixing, it was suggested that the mixing pipe should be inserted in the form of two branches between the first air-heating stove and the furnace (see diagram). In this way, a good mixing of cold and hot air was ensured and sharp fluctuations of the temperature in the air main were eliminated. The service life of the switches of the hot-blast main was increased.

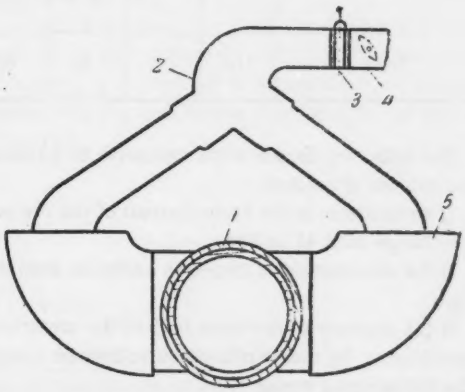


Figure. Diagram showing the connection of the mixer pipe with the hot-blast main; 1) hot-blast main, 2) mixer pipe, 3) shut-off valve, 4) throttle valve, 5) lined part of the branch pipe.

* * *

INCREASING THE OPERATING EFFICIENCY IN THE CHARGE SECTION OF THE BLAST-FURNACE SHOP

K.M. Kinyapin and L.Ya. Shparber

Magnitogorsk Metallurgical Combine

With the increase in pig-iron output at the Magnitogorsk Metallurgical Combine the amount of materials charged into the blast furnaces increased. In 12 years (1946-1958) it almost doubled (except coke). The number of workers employed in the charge section did not increase in that time but, on the contrary, decreased (see Table).

This reduction in personnel was the result of several organizational and technical measures carried out at the blast-furnace shop. In 1947, coke began to be delivered by transfer car instead of by locomotive. In this way, the number of workers employed on the delivery of coke to to the shop was reduced. The automation of the elevators for small coke, carried out in 1949, made it possible to free more than 50% of the workers engaged in the skip pit and the automation of the coke discharge from the silo made another few percent of workers free for other duties.

The automation of the skip-hoists, carried out in 1949-1950, made it possible to dispense with all the workers in this section. After the adoption of the delivery of coke by conveyor, the workers on this operation were released too. From 1954 onward the workers engaged on bin cleaning were engaged on cleaning skip-pits (two men per shift). Since last year, this work has been done by four men during the day shift only.

Occupation	Year												
	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958
Foremen of workers employed at the bins	100	87,5	50	50	50	50	50	87,5	137,5	50	50	—	50
Loaders	100	63,5	54	52	50	48	48	48	48	48	48	47	37,5
Workers engaged on bin cleaning	100	200	200	200	160	124	124	124	133	140	142	122	56
Silos operators	100	100	100	—	—	—	—	—	—	—	—	—	—
Scale-car operators	100	100	100	102	116	116	121	140	165	164	162	160	170
Skip-hoist operator	100	100	100	84	50	—	—	—	—	—	—	—	—
Workers in skip pit	100	100	100	43	33	33	38	33	—	—	—	—	20
Total	100	94	89	80	73	63	64	69	72	69	69	64	59

The following factors were conducive to a reduction in the number of loaders:

1) an increase in the sinter content of the ore portion of the charge from 40 to 90%;

2) the elimination of iron-free additions from the charge;

3) the delivery of the main bulk of the materials to the stockhouse by means of automatic hoppers designed by the Kaliningrad Works;

4) a regular delivery of charge materials;

5) the introduction of radio-communication in the charge section;

6) an indication of the level of the charge material in the bins by means of light signals.

In 1959, the following new measures aimed at further increase in operating efficiency will be carried out in the charge section: combining the duties of the loader and the bin-cleaning worker and changing the work schedule on the cleaning of the stockhouse. The removal of coke fines will be the duty of personnel of the railroad shop. All this will make a further reduction in the number of workers and an increase in operation efficiency possible.

* * *

IMPROVING THE QUALITY OF STEEL

D.A. Smolyarenko

Central Scientific Research Institute of Ferrous Metallurgy (TsNIIChM)

Reducing the amount of defective product and improving the quality of steel constitutes an important source for increasing the efficiency of steelmaking furnaces and increasing the output of steel at the existing plants.

The extraordinary Twenty-first Congress pointed out that it is necessary "...to increase the responsibilities of the management for improving all qualitative characteristics..., in particular for decreasing the cost and improving the quality of the product."

Nevertheless, it still happens occasionally that the steel supplied does not conform with the standard specifications and technical requirements. There is a large quantity of substandard "zero" grade steel produced. For instance, the "zero" grade steel at the Bessemer shop of the Petrovskii Factory amounted to 16.7% of the total output in seven months of 1958, and at the Bessemer shop of the Krivoi Rog Factory the "zero" grade steel in six months of 1958 contributed 20% of the total output.

The use of oxygen in the steelmaking processes at these works should result in a new and better quality of the steel produced. Preliminary results confirm the desirability of using Bessemer steel for the production of speical shape sections, rails and wire rods. Unfortunately, these works do not yet produce steel sheet, steel for structural members, process equipment and rivets.

It is well known that in Austria, Bessemer steel made with the use of oxygen is approved for all purposes, including ship building. In the USA, in spite of the short testing period, the ASTM approved a series of standard specifications for this steel for various purposes, including very deep drawing.

Within the next few years the output of Bessemer steel made with the use of oxygen will be increased. Therefore, it is essential to systematize and investigate extensively the qualitative characteristics of this steel in service.

TABLE 1

Characteristics of 45 Steel Made at Different Factories

Factory	Number of heats tested	Number of heats (in %)	
		of ultimate tensile strength of 64 kg/mm²	of percentage elongation below 17%
Chelyabinsk Metallurgical Factory	1049	0.5	5
"Krasnyi Oktyabr'" Metallurgical Factory	1982	4.5	1.5
Zlatoust Metallurgical Factory	1364	0.1	2.7
Serov Metallurgical Factory	427	2.5	5
Magnitogorsk Metallurgical Combine	346	14	1
Kuznetsk Metallurgical Combine	936	3	0.2

We must ensure that every steel grade, at whatever metallurgical works it is produced, is of uniform and standard properties.

Table 1 shows the characteristics of steel 45 made at different factories. Similar data could be quoted for many other establishments. With a view to compiling new standard specifications for ordinary-quality steel, information from the most important works was studied. From the data obtained, it transpired that, for steel of the same grade and for rolled product of the same thickness, the amount of product rejected on account of the yield point varied from 3.6% at the Nizhne-Tagil Metallurgical Combine to 45% at the Kuznetsk Metallurgical Combine; and on account of the percentage elongation: from 10.1% at the Kuznetsk Metallurgical Combine to 19.2% at the Nizhne-Tagil Metallurgical Combine (for sheet steel), and up to 38.5% at the Petrovskii Factory (for angle steel).

These results indicate the unsatisfactory quality of steel, and therefore higher standards for mechanical properties of steel cannot be introduced although the adoption of higher standards would result in very substantial savings in the national economy.

The smallest amount of rejected material and steel losses are shown by the steelmaking shops of the Magnitogorsk Metallurgical Combine, %:

	Semiannual period						
1940	1950	1951	1954	1955	1956	1957	1958
5,5	1,62	1,66	0,54	0,49	0,47	0,38	0,34

In the first six-month period of 1958, the amount of rejected product constituted 0.64% at the "Azovstal'" Factory, 0.79% at the "Krasnyi Oktyabr'" Factory, 0.89% at the Kuznetsk Combine, and 1.38% at the Nizhne-Tagil Metallurgical Combine. A substantial amount of rejected products and high metal losses are still shown by the steelmaking shops of the Petrovskii, Krivoi-Rog, Dzerzhinskii, and Alchevsk Factories.

The steel losses cause a variation in the actual cost of carbon steel and in the input of metal-containing charge per one ton of steel (Table 2).

TABLE 2

Actual Cost of Carbon Steel, Losses Due to Defective Material and the Consumption of Metal Charge

Establishment	Consumption of metal charge, kg/ton	Total expenditure on processing 1 ton of steel, rubles	Actual cost of 1 ton of steel, rubles	Losses (included in the actual cost of steel) due to rejected product, per 1 ton of steel, rubles
Magnitogorsk Combine	1075	63.61	237.43	0.90
Kuznetsk Combine	1067	62.58	318.61	1.03
Nizhne-Tagil Combine	1103	88.63	371.49	4.57
Petrovskii Factory:				
Open hearth production	1120	117.03	394.56	1.58
Bessemer production	1154	87.26	471.52	2.62
Krivoi-Rog Factory:				
Bessemer production	1204	172.10	544.99	6.13

The difference in the quality of the product of individual shops is explained by the fact that the technological instructions are not strictly observed.

Out of the total amount of rejected steel product in 1957 (analysis based on information from 26 factories) defective ingots detected directly at the shops constitute 16.5%; out of this amount 4.4% of the ingots were rejected owing to incorrect chemical composition, 12.1%—due to cracks, scabs, pipe, and other defects; 35.2%—owing to accidental losses during casting. The material rejected because of steel defects detected during the first rolling process constituted 48.3%.

The elimination of defective production and a strict observance of delivery dates according to plan can by achieved at all steelmaking shops. This was proved several years ago at the Kuznetsk Metallurgical Combine by the work of the well-known steel melter foremen, now heroes of Socialist Labor, M.M. Privalov and I.G. Mogilevtsev. For many years, the steel-melter teams led by these two men turned out perfect products with the specified composition of the steel grades being strictly maintained.

In the past three years, the production of 15 new steel grades and 42 new economic steel sections has been mastered at the Kuznetsk Combine.

N.V. Pereverzev, steel melter of the "Azovstal'" Factory, has shown valuable initiative for a drive toward an improvement in the quality of steel, a reduction in defective product and an increase in the output of first class product.

The Socialist Competition initiated by him should result in the elimination of defective product, an improvement in industrial discipline and in ensuring a most strict control on the maintenance of process conditions at all stages of production.

For an improvement in the quality of steel several factors are especially important: a constant uniform quality with regard to chemical composition and temperature of all charge materials, in particular pig iron; an accurate weighing of pig-iron and charge materials; a calculation of charge materials on the basis of the actual analysis of the materials charged into the steelmaking furnaces; keeping a uniform composition of the charge for each steel grade; a strict maintenance of the thermal and process regime of melting and casting as specified in the technological instructions.

It is important to improve the quality of the charge materials, in particular at factories in the South. The quality of iron ore designated for the open-hearth process is especially important. At present, this ore does not gain the approval of the steelmakers either with regard to its chemical composition (10-12% SiO_2), or with regard to its physical properties (a large amount

of fines). As early as 1957, the All-Union Conference of Steel Melters recommended the replacement of ore by fluxed sinter.

As early as 1949, the study of the problem of using sinter in the charge of the open-hearth furnace was started at the Magnitogorsk Combine. Later on, it was established that the replacement of iron ore and limestone by sinter of 2-2.5 basicity (including sinter obtained from sulfur-containing ores) during the charging period does not impair the desulfurization process, but improves the dephosphorization of the steel and shortens the melting period of the charge by 9.6% and the total time of the heat by 4.9%. M.A. Yarkho's suggestion that the ore and limestone should be replaced by ore-and-limestone briquettes appears to be very promising.

The optimum operating conditions for charging and heating the charge before the addition of hot metal and for the process of hot metal addition make it possible to ensure a standardization of the slag formation process, to control slag removal in the course of the heat, to obtain smaller fluctuations in the composition of slag and steel at the time of melting, and to reduce the amount of lime added during the finishing period.

It is very important for the steel melter to determine what is meant by the term "quality steel". Some people assume that "quality steel" means only alloy steel, others relate this term to the price of the steel, i.e., up to a certain price limit it is ordinary steel and above that limit it is quality steel; still others evaluate "quality steel" by the treatment and, in particular, the "finish" of the surface of the steel or rolled product.

The term "quality steel" includes the chemical composition, macro-and microstructure and a number of technological and mechanical properties. "Quality steel" is not limited to alloy steels only. On the contrary, iron-carbon alloy, free from any additions, including alloying elements as well as nonmetallic and gaseous inclusions, should be regarded as "quality steel" in the highest sense of the word.

The main characteristics of "quality steel" are purity with respect to harmful contaminations; the density and continuity of the structure throughout the whole bulk; purity with respect to nonmetallic substances, including oxygen content. It is also generally considered that steel with high mechanical qualities and a special chemical composition should be accepted as "quality steel".

The term "quality steel" should be determined by the technical requirements which include definite limits of chemical composition, i.e., carbon, manganese, silicon, sulfur, and phosphorous content. Steel made to comply with the technical specifications but not conforming to the minimum requirements for "quality steel" should be classified as ordinary steel.

At present, almost all carbon steel made in the form of plate, rolled sections and tubes is hot rolled.

Many investigations have shown that there is considerable scope for improving the strength and toughness of carbon steel. The heat treatment of rimmed and killed carbon steel (heating the steel above the critical point and then cooling it in water) will make it possible to improve these properties and to achieve savings in steel of up to 20-30% owing to the use of steel plates, sections and tubes of smaller cross-section area but made of stronger steel. The use of the heat-treated carbon steel instead of low-alloy steel in several industrial fields will also result in a considerable saving of alloying additions (ferromanganese, silicomanganese, ferrotitanium, etc.).

The expenditure on the thermal treatment, which will more than pay for itself by the savings in steel, can be reduced still more by means of applying the thermal treatment to sections reheated for rolling after they have been cooled to approximately 600°C. The effectiveness of the application of the thermal treatment to carbon steel is quite apparent from the results (Table 3 and 4) obtained by the employees of the TsNIIChM together with the personnel of the Nizhne-Tagil Metallurgical Combine.

TABLE 3

A Comparison of the Mechanical Properties of Hot Rolled (numerator) and Hardened (denominator) Carbon Steel (3kp)

Section	Ultimate tensile strength kg/mm²	Impact strength a_k, kg/cm², at temperature, °C	
		+20	−40
Channel No. 14	42—43 / 56—60	17 / 20—22	2,0—2,5 / 16,8—17,5
Channel No. 20	40—41 / 56—59	17—20 / 21—24	2,7—0,6 / 18,0—19,0

Thus, by means of quenching 3kp steel in water, it is possible to raise the yield point by 30-50%, to increase the impact strength sharply at a temperature below zero and to reduce its susceptibility to aging. Heat-treated killed steel has better properties than hot-rolled killed carbon-steel of the same carbon content.

The research work carried out at TsNIIChM since 1947 shows that the use of quenched rimmed carbon-steel instead of killed steel results in an additional 8% saving of steel owing to a reduction in hot top and an improvement in the surface of ingots. Because of the great importance of the heat-treatment of carbon steel to the national economy it is essential to speed up the construction of heat-treatment shops for treating steel plate at several metallurgical works, first of all at the Kuznetsk, Magnitogorsk, and Nizhne-Tagil Combines and the Alchevsk Factory.

The planned figures for the development of the national economy of the USSR in 1959-1965, passed by the Twenty-first Congress of the CPSU, found a magnificent

TABLE 4

A Comparison of the Mechanical Properties of Hot-Rolled (numerator) and Hardened (denominator) plates of 3kp Carbon-Steel

Heat	Plate thickness, mm	Ultimate tensile strength kg/mm²	Yield point kg/mm²	Percentage area reduction, %	Impact strength kg./cm² at temperature, °C			Impact strength kg./cm² after aging at temperature, °C	
					−20	−40	−60	+20	−20
A	13	41.0 / 48.5	26.0 / 37.5	25.0 / 18.0	6.0 / 8.6	1.25 / 6.9	— / 6.0	4 0 / 7.85	0.75 / 4.10
A	20	40.2 / 46.7	22.7 / 33.2	28.0 / 20.0	1.3 / 7.0	0.9 / 6.6	— / 4·4	1.5 / 8·2	0.37 / 4.50
A	40	43.0 / 46.5	20.0 / 30.6	27.2 / 24.3	0.8 / 8.7	0.9 / 6.9	— / 5·3	0·75 / 9.30	0.65 / 5·00
B	12	42.2 / 52.5	28.2 / 37·0	24.2 / 17.0	4.1 / 8.0	1.65 / 5.5	— / 4.5	4·0 / 7.8	0·50 / 4.25
B	20	42.2 / 49.2	29.2 / 35.2	24.2 / 21.2	3.3 / 8.5	1.3 / 6.7	— / 6.5	2.5 / 8.0	0.45 / 4.60

response in the productivity rise in our country. Workers in the iron and steel industry will exert all their efforts to fulfil the tasks outlined by the Party. The movement, initiated by outstanding steel melters of our country for a sharp improvement in steel quality has enormous significance for the national economy. The technical level achieved by our iron and steel industry makes it possible to solve the most complex and important problems of improving the quality and durability of steel.

* * *

THE USE OF SILICOCHROMIUM FOR THE PRODUCTION OF CHROMIUM STEEL

V.E. Sokolov, V.I. D'Yachkov, A.E. Sokolov, and I.G. Fadeev
Ural Polytechnical Institute and Serov Metallurgical Combine

A study of the use of silicochromium (3.1% C; 48.0% Cr; 19.7% Si; 0.03% P) in the production of 15Kh, 20Kh, 20KhN3A, and 20Kh2N4A steel grades was carried out at the A.K. Serov Metallurgical Combine. The experimental heats differed from the ordinary ones only in the method of deoxidation and in the alloy addition to the metal in the furnace.

For the ordinary heats, 45% ferrosilicon in the amount of 1.5-2 kg/ton of steel was added during the preliminary deoxidation; then 10% ferrosilicon (12-18 kg/ton) and silicomanganese (3-6 kg/ton of steel) was introduced. In all, 0.25-0.30% silicon was introduced into the steel (without taking into account the losses in burning). At the same time, the input of silicomanganese is determined by the necessity for increasing the content of the manganese in the steel from 0.20-0.28% to the required content in the finished steel. Five minutes after the addition of the silicomanganese, low-carbon ferrochromium was introduced into the metal bath and, after a suitable period, the steel was tapped.

Two ways of using silicochromium for the deoxidation and alloying were tried: 1) Silicochromium (12-15 kg/ton of steel) was introduced into the boiling bath and then ferromanganese and ferrochromium were added (23 heats); 2) silicochromium (12-15 kg/ton of steel) was introduced into the bath, which was first deoxidized with ferromanganese, and then ferrochromium was added (five heats).

The amount of ferromanganese was calculated in the same way as the amount of silicomanganese used for the ordinary heats. The same amount of silicon (0.25-0.30%, without taking into account the loss in

burning) as that introduced with all the deoxidizers in ordinary heats was introduced into the steel with silicochromium in the experimental heats. Ferrochromium was added to steel in the amount required for obtaining the final desired content of chromium in the finished steel.

The steel in the ordinary and in the experimental heats was finally deoxidized in the ladle with 45% of ferrosilicon and aluminum (0.8-1.0 kg/ton of steel).

In the course of the deoxidation of steel and of the introduction of alloying additions to steel in the furnace, the composition of the slag varied in the same way for the experimental heats as for the ordinary ones; the concentration of Fe_2O_3, SiO_2, and Cr_2O_3 increased, and that of FeO decreased. In the experimental heats, as well as in the ordinary ones, no complete uniformity of the steel composition in the bath was achieved during the preliminary deoxidation and alloying. When silicochromium was introduced into the boiling steel, the distribution of the chromium in the bath was more uniform than for the heats produced by the second method. The distribution of manganese in the steel in the bath was more uniform when the silicochromium was added according to the second method. Thus, in one of the heats made according to the first method, the samples of steel* taken from two levels of the bath before tapping contained 0.98% and 0.96% chromium, respectively, and in the heats made according to the second method—the samples contained 0.93% and 0.76% chromium respectively. The manganese content in the same samples was: 0.94 and 0.78% for the heats made according to the first method and 0.52 and 0.51% for the heats made according to the second method.

TABLE 1

Loss of Manganese, Chromium and Silicon in the Experimental and Ordinary Heats

Steel grade	Heat	Number of heats	Loss of element, %		
			Mn	Cr	Si
15Kh	Ordinary	8	32.50	16.80	38.30
	Experimental	5	40.90	30.80	48.00
20Kh	Ordinary	17	21.30	16.77	38.30
	Experimental	10	28.60	14.20	39.20
20KhN3A	Ordinary	6	24.00	11.50	45.10
	Experimental	7	35.80	13.90	42.30
20Kh2N4A	Ordinary	8	16.60	8.10	37.90
	Experimental	6	27.20	20.60	42.60

It is seen from the results in Table 1 that the loss of manganese in the experimental heats was slightly higher than in the ordinary ones. It is obvious that the manganese loss from steel when silicochromium is introduced according to the second method should be higher than for the first method. Actually, it was not possible to establish this fact because of the small number of heats made according to the second method. Therefore, the mean values of manganese loss in the heats where silicochromium was introduced according to the first and second methods are shown in Table 1.

Neither was the difference in the loss of chromium and silicon in the heats made according to the different methods of introducing silicochromium established.

Since the amount of carbon which was introduced with ferroalloys into the bath was higher in the experimental heats, the deoxidation of steel was started when its carbon content was lower. The average carbon content in the steel before the deoxidation was 0.11-0.15% in the experimental heats as compared with 0.12-0.15% for ordinary heats. During the production of 20KhN3A steel, the carbon content in the steel before the deoxidation was the same for the ordinary and the experimental heats (0.15%).

It is known that silicochromium has a lower specific gravity than low-carbon ferrochromium. This, apparently, affects the loss of chromium and silicon, especially when the slag has a high concentration of iron oxides which depends mainly on the concentration of carbon in the steel. With the decrease in the carbon content in the steel the concentration of iron oxides in the slag increases, and it does so especially when the carbon content is less than 0.13%.

This fact explains the higher loss of chromium and silicon in the experimental heats of 15Kh and 20Kh2N4A steels and almost equal loss in the experimental and the ordinary heats of 20Kh and 20KhN3A steels.

The phosphorus content in the finished steel from the experimental heats was 5-30% lower than in the steel from ordinary heats. This was mainly due to the elimination of the addition of 10% ferrosilicon, which contains up to 0.15% phosphorus, into the steel bath of the experimental heats.

The change in the content of oxygen and of contaminations in steel during deoxidation and alloying was studied on samples of steel taken from the furnace, and on samples taken from billets after the ingots were rolled. The oxygen content was determined by the aluminum method, and the content of contaminations was determined by metallographic and chemical methods. Steel samples were taken from the furnace by means of closed-type sampling vessels. In the finished steel, only the content of oxide and sulfide contaminations was studied by means of the metallographic method.

For the experimental heats as for the ordinary ones, the rate of decrease in the oxygen content in the steel was highest at the beginning of the preliminary deoxidation. In the course of the deoxidation the rate de-

*Metal samples were taken by means of closed-type sampling vessels, mounted on a special rod.

creased. It is significant that the rate of decrease in the oxygen content at the beginning of the deoxidation was higher for the experimental heats than for the ordinary ones. At the same time, when silicochromium was introduced into the boiling steel, the rate of decrease in the oxygen content was not lower than in the case when silicochromium was introduced into the steel which had previously been deoxidized with ferromanganese. The change in the composition of contaminations after the preliminary deoxidation of steel is shown in Tables 2 and 3.

TABLE 2

Variation in the Composition of Oxide Inclusions in the Course of the Deoxidation and Alloying of Steel (Silicochromium was Introduced According to the Second Method)

Steel sampling after the introduction of silicochromium	Composition of inclusions, %				
	SiO_2	Al_2O_3	FeO	MnO	CrO
After 5 min	44.05	3.59	3.58	45.60	3.18
" 16 "	49.97	4.59	2.82	39.36	3.26
" 20 "	51.45	4.79	4.11	35.60	3.88
" 32 "	50.65	2.56	2.32	38.90	4.66

TABLE 3

Variation in the Composition of Oxide Inclusions in the Course of the Deoxidation and Alloying of Steel from an Experimental Heat (Silicochromium was Introduced According to the First Method)

Time of sampling steel after the introduction of silicochromium	Composition of the inclusions, %				
	SiO_2	Al_2O_3	FeO	MnO	CrO
After 4 min . . .	71.50	1.24	7.15	11.63	6.18
" 7 " . . .	75.10	1.68	2.38	15.70	7.62
" 16 " . . .	67.80	1.10	4.18	22.10	4.84
" 36 " . . .	49.55	0.99	6.53	38.17	4.76

As is seen from the composition of the contaminations, when silicochromium is used it is mainly the silicon from the silicochromium which takes part in the deoxidation. Chromium, on the other hand, even when silicochromium is introduced into the boiling steel, plays but a small part in the deoxidation process. This fact is indicated by the high concentration of silicon oxides and low concentration of chromium oxides in the stabilized products of deoxidation. The deoxidation product contained the same amount of chromium oxides as iron oxides.

A more rapid reduction in the oxygen content in the steel at the beginning of deoxidation for the heats made according to the first method was due to the fact that the deoxidation of steel with silicon in the experimental heats took place at a higher concentration of manganese. Therefore, at the beginning of deoxidation by means of silicochromium a more extensive formation of silicates with a high content of manganese oxides took place than at the beginning of the deoxidation by means of 10% ferrosilicon in the ordinary heats. This is indicated by a higher concentration of manganese oxides in the deoxidation products. Silicates with a high quantity of manganese oxides rapidly passed into slag.

The rapid decrease in the oxygen content in the steel at the beginning of the deoxidation when silicochromium was introduced into the boiling bath is due to another factor. Immediately after the addition of silicochromium, when it is introduced into the boiling steel, the deoxidation products contain a smaller amount of manganese oxides and a larger amount of silicon oxides than in the case when silicochromium is introduced after the addition of ferromanganese.

The deoxidation products stabilized in the steel in the form of inclusions had a globular form (on the metallographic sections) for both types of heats. The amount of large globular inclusions in the specimens taken after the addition of silicochromium into the boiling steel was not less than in the case when silicochromium was added into the steel which had previously been deoxidized with ferromanganese. The formation of a great amount of large-size inclusions and the rapid decrease in oxygen content in the steel immediately after the addition of silicochromium to the rimmed metal can be explained only by the effect of mixing.

When the silicochromium was introduced after the addition of ferromanganese no vigorous mixing of the bath was observed. However, after the addition of silicochromium to the boiling steel, an intensive mixing of the bath was still taking place owing, mainly, to the evolution of gases since, at the same time, the decarbonization of steel was occurring. The mixing speeded up the coalescence and the floating-up of the deoxidation products. Therefore, at the beginning of deoxidation, when silicochromium was introduced into the boiling steel, the rate of decrease in the oxygen content was not lower than in the case when silicochromium was introduced into the steel which had already been deoxidized with ferromanganese.

A more rapid decrease in the oxygen content of the steel at the beginning of the deoxidation ensures a lower total content of oxygen in steel before tapping. It follows that the finished steel from the experimental heats should contain less oxide contaminations, and this is confirmed by the results shown in Table 4. It is seen from Table 4 that the amount of sulfide contaminations does not depend on the order in which the deoxidation and alloying of the steel is carried out.

An inspection of the surface and the macrostructure of billets, as well as mechanical tests on the specimens from the experimental and ordinary heats, showed that

TABLE 4

Inclusions in Billets from the Top End of Ingots from Experimental and Ordinary Heats

Steel grade	Heat	Sequence of preliminary deoxidation and alloying	Inclusions, mark					
			specimen 1 (periphery of ingot)		specimen 2 (half radius of ingot)		specimen 3 (center of ingot)	
			S	O	S	O	S	O
20Kh	Experimental	SiCr + FeMn	1.90	1.90	3.52	2.03	2.77	1.98
20Kh	Ordinary	45% FeSi + 10% FeSi + + SiMn + FeCr	2.20	2.00	3.15	2.13	3.12	2.10
20Kh2N4A	Experimental	FeMn + SiCr	1.95	2.40	2.00	2.00	1.93	1.75
12Kh2N4A	Ordinary	45% FeSi + 10% FeSi + + SiMn + FeCr	2.00	2.35	3.00	2.10	2.35	2.23

the substitution of silicochromium for ferrosilicon and ferrochromium had no effect.

When silicochromium was used, the number of cold additions into the bath during the production of 15Kh steel was reduced by 7.5 kg/ton, and during the production of 20Kh, 20KhN3A, 20Kh2N4A steels – by 12 kg/ton of steel.

By replacing ferrosilicon and ferrochromium by silicochromium, it was possible to reduce the cost of the deoxidation and alloying of one ton of steel by 9 rubles, 70 kopeks for 15 Kh steel, by 14 rubles for 20Kh steel, and by 12 rubles for 20KhN3A and 20Kh2N4A steels.

By carrying out the preliminary deoxidation and alloying of the experimental heats simultaneously, the time period between the beginning of deoxidation and the beginning of alloying with chromium was eliminated. This time period constituted 10-12 minutes for the ordinary heats. Owing to some practical causes, the actual reduction in the time taken for the preliminary deoxidation and alloying, when silicochromium was used, was smaller. The time period constituted four minutes in the production of 15Kh, 20Kh, 20KhN3A steels and 9 minutes in the production of 20Kh2N4A steel.

It should be pointed out that when silicochromium of the composition given above is used, the finishing period of the heat is extended owing to a larger amount of carbon being introduced into the bath by the ferroalloys during the deoxidation and alloying. This indicates that it would be advantageous to use silicochromium with a carbon content of less than 2% in the production of low carbon steel and this would also result in a smaller loss of chromium.

* * *

THE USE OF TITANIUM-CONTAINING WASTES INSTEAD OF FERROTITANIUM

V.A. Khryukina, M.G. Bryunetkin, E.I. Korablev, and L.A. Kamkina

Chelyabinsk Metallurgical Works

The use of alloy-containing wastes in the production of alloy and high-alloy steel reduces the cost of steel considerably owing to the reduction in the consumption of expensive ferroalloys, and makes it possible to increase the output of alloy steels without increasing the production of ferroalloys.

At the Chelyabinsk Metallurgical Factory, an investigation was carried out into the possibility of using high-titanium waste material (in the form of turnings and sheet trimmings in place of FeTi in the production of titanium-containing steels, grades 30T and 18-40KhGT. To achieve complete decreasing of the waste products, they were heated for one hour in boxes which had been heated beforehand to 350-400 °C.

Steel was made in 100-ton open-hearth furnaces by the scrap-ore process; the input of liquid pig iron constituted 60-65% of the charge, the fuel was mixed (coke-oven and blast-furnace) gas, coal tar being used for

carburetting. The steel was bottom-poured into 6.2 ton ingots. The 30T steel ingots were rolled into slabs, and the 18-40KhGT steel ingots, after being passed through the blooming mill, were rolled on conversion mills into 33-160 mm rounds.

Up to the time of the deoxidation and alloying of the steel in the ladle, the experimental heats were carried out according to the existing technical instructions. The final deoxidation and alloying of 30T steel in the ladle was carried out according to the instructions in the following way: when the ladle was filled with steel to a height of 200-300 mm, one third of the total aluminum amount was introduced, then ferrotitanium and, at the same time, the remaining amount of aluminum were added.

In the experimental heats, the titanium-containing waste and one third of the total amount of aluminum was placed on the bottom of the ladle, and the remaining aluminum was added into the ladle when it was half filled with steel. This is equivalent to adding approximately 500 g of aluminum per ton of steel.

28 heats of 18-30KhGT steel were produced; in 18 out of these heats the titanium additions were introduced in the form of turnings and in 10 heats in the form of sheet trimmings. In 17 heats 400 g of aluminum per ton of steel were added, in two heats 200 g per ton of steel were added and in 9 heats no aluminum was introduced. The following results were obtained:

1. Turnings and other waste materials were completely dissolved by the time the ladle was one third full.

2. The content of titanium in the finished steel from all heats was within the limits given by the technical specifications.

3. Titanium loss in burning amounted to an average of 63.5% when turnings were used, and 57.5% when waste from sheet steel was used. At the same time for heats produced with the use of FeTi the titanium loss in burning constituted 52.5%. The reason for the higher titanium loss for the heats in which titanium-containing wastes were used was a larger surface area per unit weight of the wastes in comparison with the surface area of the ferrotitanium.

4. The quality of the surface of the rolled steel made with the use of titanium waste was considerably higher.

The results given in Table 1 show that the output of groups I and II of slabs from heats carried out with the use of wastes was 1.5 times as large and the amount of material rejected because of surface defects was almost half as large as for the heats in which FeTi was used.

According to the technical instructions, aluminum is not added when steels of 18-40KhGT grades are made because the FeTi added contains 6-7% Al. This is equivalent to adding approximately 500 g of aluminum per ton of steel.

28 heats of 18-30KhGT steel were produced; out of these in 18 heats the titanium additions were introduced in the form of turnings, and in 10 heats in the form of sheet trimmings. In 17 heats 400 g of aluminum per ton of steel were added, in two heats 200 g per ton of steel were added and in 9 heats no aluminum was introduced. The following results were obtained:

1. In three heats the content of aluminum in the finished steel was lower than specified by GOST (0.05-0.6% compared with 0.08 %). The deviation from the required chemical composition was a result of the inadequate quantity of titanium-containing wastes and a high loss of titanium (81-83%).

TABLE 1

Comparative Data on Smelting of 30T Steel

Type of heat	Number of heats	Rejected product, %	Slab output according to group, %				
			I	II	III	IV	V
With the use of titanium-containing waste	26	0,89	68,5	26,3	5,0	0,3	
With the use of FeTi	46	1,67	46,6	38,5	14,2	0,7	

TABLE 2

Loss of Titanium in the Course of the Production of 18-30KhGT Steel

Form in which titanium was introduced	Titanium lost (%) for the heats *		
	without aluminum addition	with aluminum addition, g/t	
		200	400
Turnings	8/77.5	2/71.0	8/67.5
Sheet trimmings	1/72.5	—	9/60.5
Ferrotitanium	3/53.5	—	—

* The numerator indicates the number of heats and the denominator the titanium loss.

2. The amount of titanium lost by burning depends on the particle size of the wastes added and on the amount of aluminum added into the ladle (Table 2). It was established that the addition of aluminum in the amount of 400 g per ton reduces the titanium loss by 10-12%. When titanium-containing wastes were used and 400 g of aluminum per ton of steel was added, the titanium loss was 7-14% higher than for the heats in which FeTi was used.

The 18-40KhGT steels made with the use of titanium-containing wastes show better properties with respect to the surface of the steel as well as to the macrostructure in comparison with the heats made with the use of FeTi.

Table 3 contains data on the surface quality and the macrostructure of steel.

TABLE 3

Comparative Data on the Quality of 18-30KhGT Steel

Type of heat	Number of heats	Rejected product, %		
		owing to surface defects of the 110 mill	owing to defects in macro-structure	total
With the use of titanium-containing waste. .	28	0,13	0,48	0,61
With the use of FeTi	77	0,24	0,52	0,76

It is seen from Table 3 that the amount of steel rejected on account of surface defects is almost half as large for steel made with the use of titanium-containing waste; there is no significant difference in the macrostructure between the two types of heat. At the same time, no relation between the quality of the macrostructure and the amount of aluminum added was detected.

An analysis of the results of the inspection of ingot surface shows that the amount of product rejected on account of surface defects constitutes 0.50-0.55% and is practically the same for heats in which no aluminum was used and for heats in which 400 g of aluminum per ton of steel was added.

The mechanical properties of the steel from all the heats made with the use of titanium-containing wastes conform to GOST requirements and technical specifications (Tables 4 and 5).

TABLE 4

Mechanical Properties (mean)of 18KhGt Steel

Heats	No of heats	Ultimate tensile strength σ_B kg/mm²	Yield point σ_S kg/mm²	ρ, %	Percentage reduction of area, ψ, %	Impact strength a_k kgm/cm²
			Minimum			
Specified limits		100	90	9	50	8
Ordinary	10	150	139.9	12.9	58.8	11.4
Experimental, without the addition of aluminum	2	148.9	139.3	13.0	57.8	13.5
Experimental, with the addition of 400 g of aluminum per ton of steel	6	153.3	143.0	13.5	57.7	10.7

TABLE 5

Mechanical Properties (Mean)of 30KhGT Steel

Heats	Number of heats	Ultimate tensile strength, kg/mm²	Yield point, kg/mm²	ρ, %	Percentage reduction of area, %	Impact strength kg/cm²	Hardenability			
							$l_{c\,9}$		$l_{c\,15}$	
							number of heats tested	for sections up to ∅ 90 mm	number of heats tested	for sections over ∅ 90 mm
			Not below							
Specified limits		150	110	9	45	6	—	30—45	—	30—45
Ordinary	11	163.4	153.6	11.6	57.6	9.1	6	33.7	5	31.6
Exptl, without adding aluminum	6	162.9	152.9	12.5	55.8	10.5	3	37.0	3	34.5
Experimental, with the addition of 200 g of aluminum per ton of steel .	2	162.7	152.0	11.4	60.3	10.7	—	—	2	30.5
Experimental, with the addition of 400 g of aluminum per ton of steel .	11	167.3	157.0	12.7	57.1	9.0	6	34.2	5	31.7

With the use of the data from the factory's estimating department an economic analysis of the application of titanium-containing wastes instead of FeTi was made. The actual consumption of FeTi in the production of 30T and 18-40KhGT steels constituted 8.7 kg/ton, and the consumption of titanium-containing wastes in the production of 30T steel constituted 3.0 kg/ton when turnings were used and 2.7 kg/ton when sheet trimmings were used. This represents a saving of 29 rubles 26 kopecks per ton of steel made with the use of turnings and 30 rubles 76 kopecks per ton of steel made with the use of sheet trimmings.

In the production of 18-30 KhGT steels, the consumption of titanium-containing wastes constituted 4.0 kg/ton when turnings were used, and 3.2 kg/ton when sheet trimmings were used. This represents a saving of 24 rubles 23 kopecks per ton of steel when turnings are used and 28 rubles 25 kopecks when sheet trimmings are used.

From the results of the experiments carried out the following conclusions can be drawn.

1. The addition of titanium-containing wastes instead of FeTi for alloying 30T and 18-40KhGT steels with titanium does not impair the quality of the steel made.

2. When titanium-containing wastes are used the steel has to be at a lower temperature (a smaller quantity of materials added into the ladle).

3. The loss of titanium depends on the particle size of the waste materials used and on the quantity of aluminum added into the ladle for the final deoxidation of the steel.

4. The use of titanium-containing wastes for alloying the steel of the 30T and 18-40KhGT type is desirable and economically advantageous.

5. Before they are used, the waste materials, in particular the turnings, must be degreased at the factories which supply them.

* * *

THE EFFECT OF THE THICKNESS OF THE PLATES INSERTED BETWEEN BRICKS ON THE SERVICE LIFE OF ROOFS

E.M. Tsygankov and M. F. Ratnikov

Vyksa Metallurgical Works

The service life of roofs is affected by the metal plates inserted between the bricks as well as by the chemical composition and mechanical properties of the bricks. In the course of operation, under the action of high temperature and the surrounding medium, the internal surface of the roof bricks absorbs iron-oxides and melts.

Experience has shown that the erosion of roof bricks takes place because of melting of the bricks, and to a great extent on account of spalling which results from the appearance of cracks in the working zone of the furnace.

The cracks in the bricks in the working zone are caused by thermal stresses and volumetric changes.

The volumetric changes are caused by the saturation of the brick surface with iron oxides from the bath and from the oxidation of the steel plates between the bricks. The thickness of the plates between the bricks in the working zone was found to increase by a factor of more than 6 compared with their initial thickness. The greater the distance from the working zone, the smaller the thickening of the plates.

With a view to establishing the effect of plate thickness on the durability of magnesite-chromite roofs in 60-ton open-hearth furnaces, rings with plates of various thicknesses and rings without plates were installed (Fig. 1).

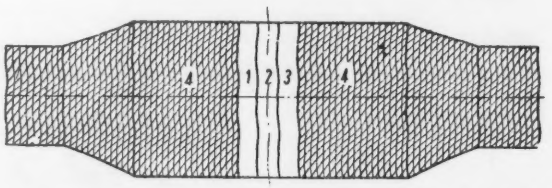


Fig. 1. Diagram showing the position of rings with plates of various thicknesses between the bricks. 1-6) Ring without plates; 2-7) ring with plates 0.3-0.5 mm thick; 3-7) ring with plates 1.5-2.0 mm thick; 4) plates 0.8-1.0 mm thick.

The erosion of the roof made of unfired magnesite-chromite bricks in rings without metal plates is shown in Fig. 2. The erosion of rings containing plates of various thicknesses is practically the same. With the plates

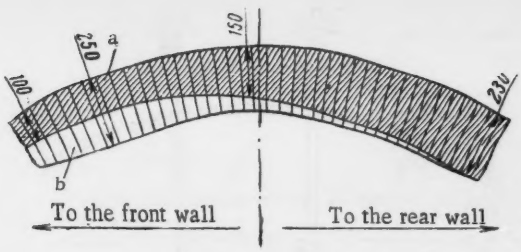


Fig. 2. Erosion of the roof made of unroasted magnesite-chromite bricks, after 427 heats: a) Rings without plates; b) rings with plates between bricks.

present, the bricks became fused together and the roof became monolithic. The increased erosion of the unfired bricks in the rings without plates is explained by the fact that the bricks did not fuse together.

The observed spalling of bricks without plates took place over the whole perimeter of the brick, whereas the spread of the spalling in the bricks with metal plates was restricted owing to the monolithic structure of the roof.

In this connection, it is worth considering the design of bricks containing two metal plates incorporated inside the brick (Fig. 3). According to information from some foreign works, this type of brick is eroded much less.

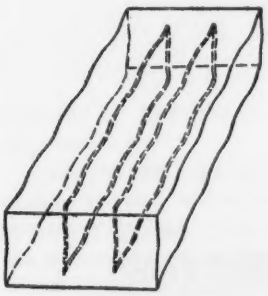


Fig. 3. Magnesite-chromite brick with metal plates incorporated inside the brick.

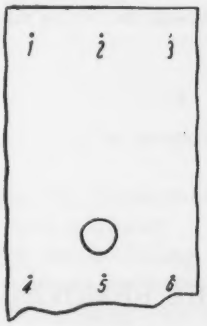


Fig. 4. Method of measuring plate thickness.

Experiments carried out on the 180-ton furnace showed that there was no significant difference in the erosion of bricks after 571 heats.

The erosion and durability of roofs depend to a great extent on their monolithic structure which is brought about by chemical reactions which join the oxidized plates with the magnesite-chromite grains of the brick. This fusion takes place over almost two thirds of the height of the brick (Fig. 5).

The relation between the strength of the junction of bricks fused together and the thickness of the plate between them was tested by fracturing the joined bricks on a tensile testing machine with a special attachment. The tests showed (Table 1) that the thickness of the plate

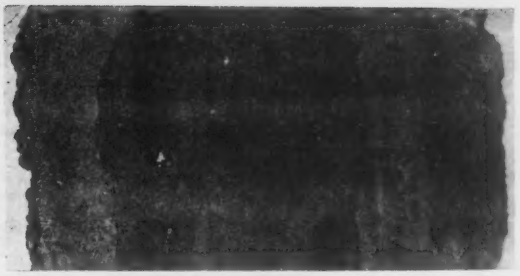


Fig. 5. Photograph of the fracture surface of the brick where it was joined with the plate.

TABLE 1

The Strength of the Fused Joints of Roof Bricks after Service

Thickness of the plate between the brick (mm)	Fracture load, kg	Area of fusion, cm²	Ultimate tensile strength, kg/cm²
Brick before use*	120	60	2
The same	140	74	1 9
0 5	700	120	5 8
0 7	400	87	4 6
1 0	500	84	5 95
1 0	350	112	3 1
1 1	150	25	6 0
1 2	300	220	1 4
1 7	200	36	5 6

* When subjecting the whole brick to the tensile test.

has no effect either on the ability of the brick to fuse together or on the monolithic structure of the roof.

It is, therefore, expedient to use plates made of roofing iron sheets, 0,5-0,7 mm thick, for insertion between the bricks. These plates cause very small volumetric stresses in the roof when they are oxidized and they reduce the heat losses through the roof.

It has been found that during operation, in the second half of a campaign, the thrust-suspension roof becomes deformed. This phenomenon depends on the loss of strength in the plates by means of which the roof is attached to the furnace structure. Usually, 1.25-1.5 mm plates are used. The strength of the plates decreases in the upper part (at the junction with the dowels) owing to extensive oxidation (Table 2, Fig. 4).

In order to maintain the strength of the plates attached to the roof structure, rings with calorized plates were installed at the 60-ton and 180-ton furnaces. To improve the ability of brick to fuse together, the lower part of the plates was not calorized.

As an experiment, on the assumption that because of the plates the roof acquires a good monolithic structure, 6 rings with metal dowels (Fig. 6) and with the bricks attached to the suspension members of the furnace were set up on one of the small furnaces. After 420 heats

TABLE 2

Final Thickness of the Metal Plates after 517 Heats (Points of Measurement as Shown in Fig. 4)

Nominal thickness of plates (mm), at points				Final thickness of plates (mm), at points				Average wear of plates (mm) during the campaign
1	2	3	mean	4	5	6	mean.	
1.25	1.21	1.23	1.23	0.74	0.90	0.85	0.83	0.40
0.96	1.00	0.95	0.97	0.45	0.51	0.53	0.50	0.47
1.34	1.38	1.29	1.34	0.95	0.81	0.86	0.87	0.47
1.27	1.30	1.31	1.29	0.90	0.86	0.75	0.84	0.45
1.48	1.51	1.45	1.48	1.10	1.05	1.12	1.08	0.40
1.15	1.18	1.14	1.16	0.85	0.70	0.65	0.73	0.43
1.20	1.16	1.21	1.18	0.80	0.83	0.75	0.79	0.39
1.31	1.40	0.35	1.35	0.70	0.81	0.78	0.76	0.59

carried out in this furnace, no changes were found in the roof.

In this way it was established that in the thrust-suspension magnesite-chromite roof it is advisable to use plates 0.5-0.7 mm thick between the bricks. These plates ensure that the bricks fuse together well and that the roof acquires a monolithic structure, and they also reduce the stresses in the roof and contribute to lowering the heat losses.

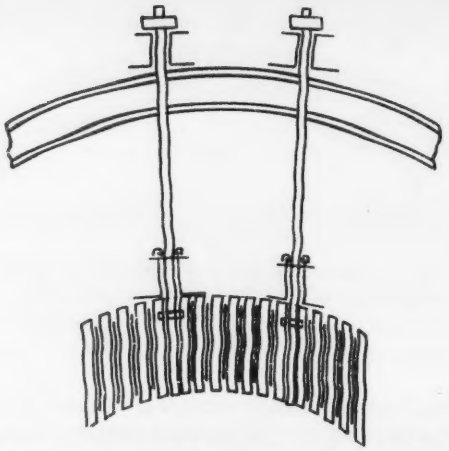


Fig. 6. Design of the thrust-suspension roof without junction dowels between the bricks.

The use of bricks with incorporated additional plates reduces the wear and increases the durability of roofs considerably. The refractory industry, in conjunction with metallurgical works, should introduce the production of these bricks as soon as possible.

With a view to increasing the durability of roofs and reducing steel consumption on their reinforcement, it is essential to continue experiments on the use of heat-resistant plates attached to the furnace structure and of dowels for joining the bricks together.

* * *

UNIVERSAL SCRAPING MACHINE FOR THE REMOVAL OF HOT SLAG

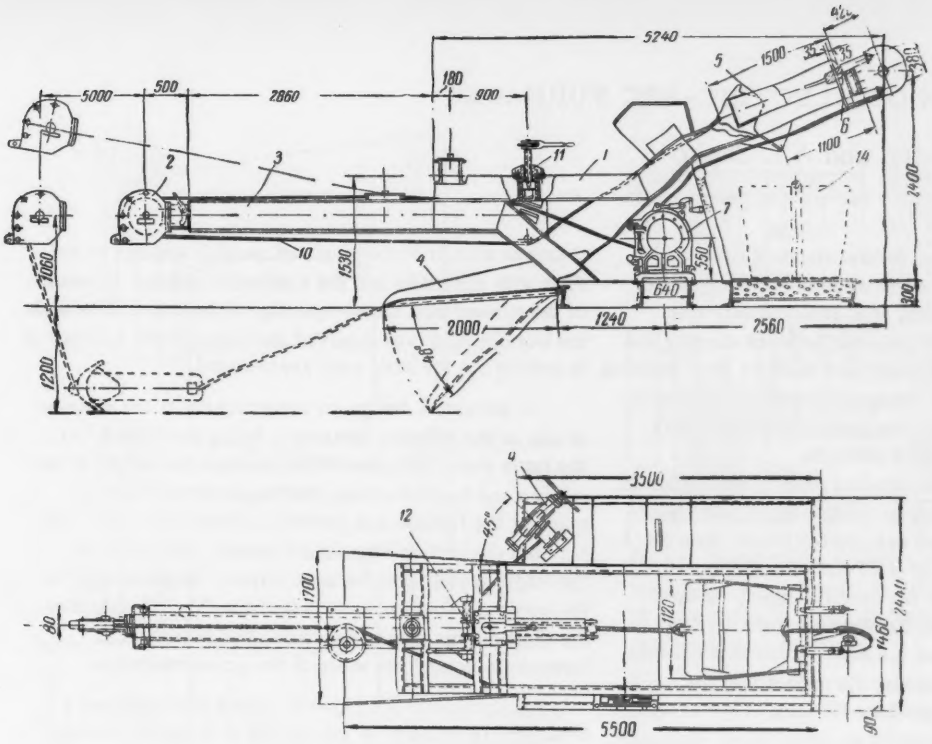
V.Z. Lavrenov

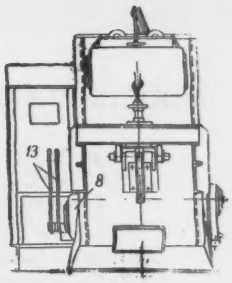
Makeevka Metallurgical Works

The existing methods of removing slag from the slag pockets of open-hearth furnaces by means of jib cranes are not very efficient; with these methods, in addition to a considerable expenditure of manual labor, one has to wait a long time for the slag and the slag pockets to cool before starting slag removal.

The existing movable scraping machines for the removal of slag from slag pockets at some works have the disadvantage that as the slag is removed from the front end of the slag pocket the equipment has to be moved toward the furnace from time to time as well as along the slag pocket in the course of slag removal; thus there is an extra loss in time and the lifting equipment is kept engaged.

A.D. Pleskanovskii, F.M. Pavlov, and P.U. Shcherba, employees in the repair shop of the metallurgical furnaces at the Makeevka Metallurgical Factory, developed a design for a universal movable scraping machine (see Figure). The extensible trunk of the machine moves on a guide rail. The scraper, with the slag, is lifted onto the front end of the frame and, at the same time, a buffer absorbs the shock of the scraper when it reaches its upper position at the moment when the slag is being tipped into the container and, in this way, a premature fracture of the rope is prevented. The front end of the shaft is lifted and lowered by means of a screw device with a layer and ratchet wheel designed for hand operation. By means of this screw device and with the use of the





Universal movable scraping machine: 1) Scraper frame; 2) trunk; 3) guide rail; 4) apron; 5) scraper; 6) buffer; 7) LDM-25 hoist; 8) electric motor; type A81-6; 9) mechanism for extending the trunk; 10) rope; 11) mechanism for lifting and lowering the front end of the trunk; 12) mechanism for rotating the trunk; 13) control levers; 14) container.

lever and the ratchet wheel, one can rotate the extensible trunk both ways.

The scraping machine is mounted on a frame made of channel beams and is placed in front of the slag pockets of the open-hearth furnace by means of lifting and transporting equipment available in the casting bay.

The maximum outward movement, lifting, lowering and turning range of the extensible trunk are designed in such a way that all the slag can be removed from the slag pocket without the scraping machine being moved from one place to another. The machine is simple to operate and is operated by one workman.

The use of the universal scraping machine during hot, medium and cold repairs resulted in a reduction in the time required for the removal of slag from the slag pocket by 1.5-2.0 days; it also resulted in a reduction in the number of workers engaged on removing the slag from the slag pockets and in making the duties of the remaining workers engaged on this operation considerably easier. According to our calculations, the total saving resulting from this innovation amounted to about 1.5 million rubles annually.

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MODERNIZATION OF ELECTRIC-ARC FURNACES

P.M. Rutberg and A.I. Sapko

"Dnepropspetsstal'" Factory and Dnepropetrovskii Metallurgical Institute

Previously, there were several standard sizes of electric-furnace shell in every steelmaking shop of the "Dnepropspetsstal'" Factory. For each standard size there was a separate set of patterns for block shaping and for laying the roof; spare blocks and roofs for each standard size had to be kept. The storage of these numerous bulky patterns, blocks, and roofs occupied considerable floor space and made normal work difficult.

At present, only three standard sizes of shells (20, 15, and 5 ton) have been retained in shop No. 1, one size (30 ton) in shop No. 2, and one size (40 ton) in shop No. 3. Owing to the unification of shell sizes the shaping of blocks and laying of roofs has become easier. In shop No. 3, the shells of the 30-ton furnaces were unified with the 40-ton shells, and the shells which thus became available were used to increase the capacity of the furnaces in shop No. 2 from 20 to 30 tons.

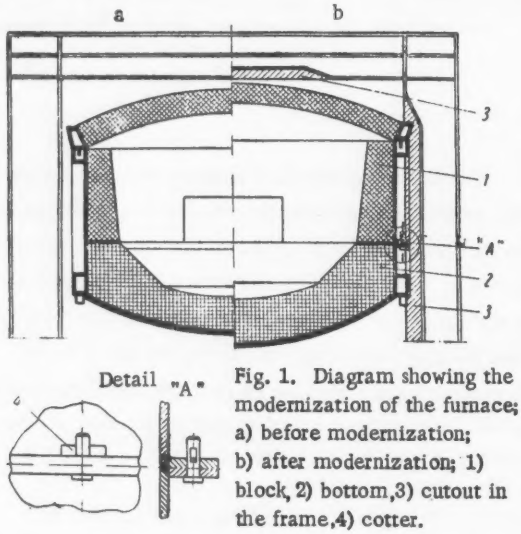


Fig. 1. Diagram showing the modernization of the furnace; a) before modernization; b) after modernization; 1) block, 2) bottom, 3) cutout in the frame, 4) cotter.

To accommodate the shell and roof of a larger size, parts of the columns and beams of the frame were cut away (Fig. 1). In the cut-away places, the structural members were reinforced and tested for strength and rigidity. However, owing to the extremely small distance between the bridge beams and the roof and to the effect of hot gases escaping from the gaps around the electrodes and impinging on the beams of the roof, the beams become heated up to a high temperature at which the steel structures cannot support the considerably higher loads due to the roof (the replacement of silica roofs by magnesite-chromite ones and the increase in the roof diameter almost double the roof weight) and due to the shaft with the masts and the electrode holders. At some of the modernized furnaces, tilting of the columns toward the heavier shaft was observed and hence some difficulties in rolling out the bath were experienced.

At present, a design for replacing the tilted columns of one of the standard furnaces is being developed. At the same time, it is planned to increase the height of the column and hence increase the height of the working space of the furnace and provide a clearance of 500 mm between the roof and the frame beams. The width of the frame is restricted because a space large enough for the convenient accommodation of the flexible cables of the short circuit has to be maintained between the furnace frame and the walls of the power substation.

An increase in the capacity of the bath involves a considerable increase in the weight of the shell, lining, roof, steel structures, and mechanisms of the furnace. At the same time it is desirable not to replace the expensive rack-and-pinion mechanism for tilting the furnace. Therefore, it is important to determine the position of the center of gravity of the furnace and the forces which act when the furnace is tilted for steel pouring and slag removal.

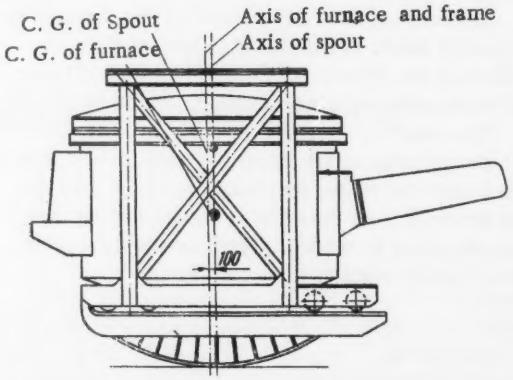


Fig. 2. Diagram showing the position of the center of gravity of the furnace and the center line of the spout.

In one case, to reduce the force required to tilt the furnace the center line of the furnace was displaced toward the furnace bay by 100 mm relative to the center line of the spout (Fig. 2). In this way it was possible not only to retain the existing tilting mechanism but also to make its operation easier although the weight of the parts to be tilted was almost doubled.

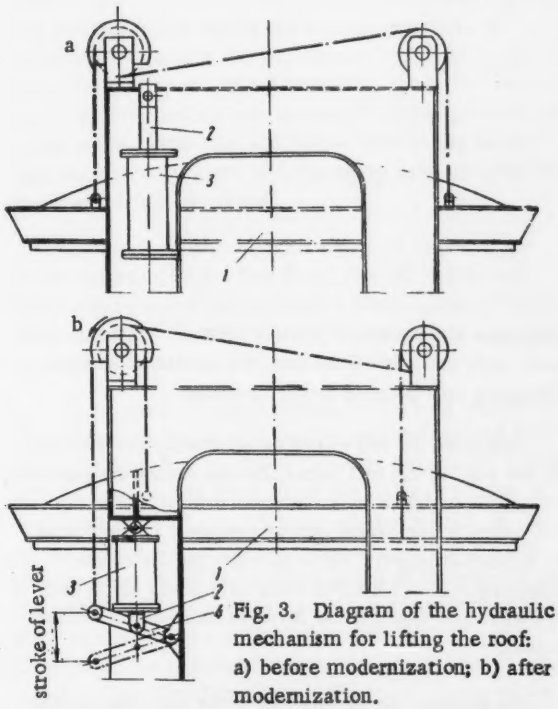


Fig. 3. Diagram of the hydraulic mechanism for lifting the roof: a) before modernization; b) after modernization.

In some cases at furnaces with hydraulic tilting mechanisms, the old hydraulic cylinders were replaced by more powerful ones.

The hydraulic mechanism for lifting the furnace roof (Fig. 3,a) has some substantial shortcomings. During the steelmaking process, the roof (1) is lowered, and the rod (2) is lifted out of the cylinder (3) and becomes covered with dust. When the roof is lifted,this dust is introduced into the cylinder with the shaft and damages the stuffing box. Hence, when the roof is lifted and the part of the cylinder between the piston and the stuffing box is under pressure, there is an extensive leakage of oil.

In the modernized hydraulic roof-lifting equipment (Fig. 3,b), the cylinder (3) is turned with its rod downward and is hinged on the frame; the rod (2) is connected to the lever (4) and, during the heat, it is retracted into the cylinder. When the roof is lifted, the part between the piston and the blind end of the cylinder is under pressure. Since the roof (1) descends under its own weight, there is no need to establish pressure in the lower part of the cylinder between the piston and the stuffing box. Hence, there is no need for a tight stuffing box. The oil from the upper part enters the lower part through the piston and is then drained directly into the tank through a tube.

In the course of operation, when the furnace was rolled into position, the bolts fastening the ring with the

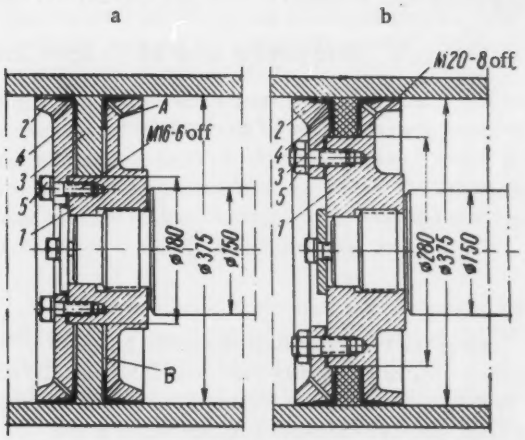


Fig. 4. Piston of the cylinder of the mechanism for rolling the furnace out: a) Before moderization; b) after modernization; 1) flange; 2), 3) rings; 4) leather sleeve; 5) bolts.

flange of the piston of the rolling-out cylinder (Fig. 4) frequently broke down; in addition, the pressure in the cylinder increased considerably (up to 30 kg/cm^2) and the oil penetrated through the openings A into the space B between the flange and the ring. With a 375 mm diameter cylinder and a 180 mm diameter ring, the force of pressure on the end walls in space B can reach 25.4 tons and this greatly exceeds the allowable load on the bolts.

To prevent the bolts from fracturing, their number was increased from six to eight and the thread from M16 to M20; the bolts were made of 45 steel instead of St3. In this way a sufficient stress was obtained for compressing the leather sleeve and for preventing the oil from entering space B.

At the same time the internal diameter of the space B was increased from 180 to 280 mm; in this way, the area which could be subjected to oil pressure (if the leather sleeve was not sufficiently compressed) was reduced and the force fracturing the pins was decreased.

In addition, in the course of furnace modernization, some other problems were solved too. On all furnaces, electrode holders of spring-clamp air-release type were installed; on some furnaces the supporting rolls of the furnace shell were mounted on roller bearings so that the operation of the rotating mechanism of the furnace was facilitated; on some furnaces the rotating mechanism was changed to one driving gear instead of two, and some other changes were introduced.

The modernization of the furnaces, described above, made it possible to reduce the idling periods of the electric furnaces, to improve operating conditions and consequently to increase the output of the electric furnaces.

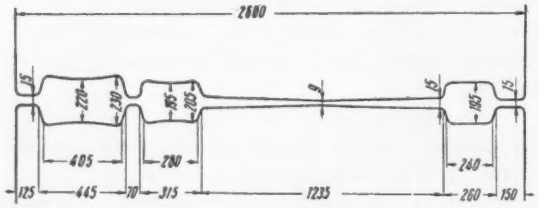
IMPROVED DESIGN OF BLOOMING MILL ROLLS

L.V. Andreyuk and M.I. Igon'kin

Magnitogorsk Metallurgical Combine
Rolled Steel and Tube Production

One of the blooming mills of the Magnitogorsk Combine consists of two two-high reversible stands driven by 7000 hp motors. Square blooms, 250 mm and 290 mm, and slabs, 135-190×530-850 mm, are rolled at the blooming mill.

In order to increase the width of the slabs rolled, to improve the durability of rolls and to increase the output of the blooming mill, it was decided to change the design of the rolls and to arrange the first pass in the middle of the roll barrel (see Fig.) instead of arranging the passes in consecutive order.



The blooming-mill roll with the first pass in the middle of the barrel.

Prior to the introduction of the new design, the part of the roll barrel for rolling slabs was of cylindrical shape. This arrangement had several disadvantages. The service life of rolls made of 60KhN steel was 7000 to 8000 tons of slabs per mm of roll wear. At the same time, the most extensive wear took place in the middle of the roll while the edges of the rolls remained practically unaffecte Therefore, when the rolled piece in the last pass was displaced toward one edge of the roll, one obtained a piece with a nonuniform thickness over its width. When, subsequently, the slabs were rolled on the continuous mill, the nonuniformity in the thickness of the piece and its crescent-like shape frequently resulted in the rolled piece being stuck between the stands, causing stoppages and defective product. Hence, after the rolls were worn down by 12-14 mm, the operation at the blooming mill became rather strenuous.

The need for roll changing is actually determined by the wear of the roll barrel; blooms constitute less than 40% of all material rolled and the service life of the box passes in the period between two roll changes may be somewhat longer. Since full-day repairs at the blooming mill are carried out every month and a half, two extra roll changes are made in the period between repairs.

To increase the service life of the rolls, the portion of the roll barrel employed for rolling slabs is given a convex shape. The contour of the convexity corresponds approximately to the contour of the wear of the cylindrical barrel. Therefore, after a certain period of operation, the rolls with a convex shaped barrel become cylindrical and then the wear proceeds in the usual way. Hence it is possible to roll a larger quantity of steel when convex rolls are used.

The permissible variation in the width of the clearance between the rolls along the barrel is 12 mm; when a cylindrical barrel is employed, the total wear of the rolls in the periods between repairs at the blooming mill and between the two roll changes in that interval (three campaigns) would constitute $12 \times 3 = 36$ mm. For the same conditions, the wear of rolls with a convex barrel may constitute $12 + 6 = 18$ mm (6 mm represents the initial convexity) during one campaign in the period between roll changes. The number of campaigns in the period between two repairs will then amount to $\frac{36}{18} = 2$, i.e., one campaign less.

Therefore, at present, one of the two roll changes in the period between the repairs of the blooming mill has been eliminated. In addition, the new roll design makes it possible to roll a larger amount of slabs when the variation in the distance between the rolls is very small and hence operating conditions are most favorable.

The rolls with a convex barrel have now been working successfully for four campaigns.

Before the change to the new design, there were some doubts as to whether the rolled piece would not stay in a stable position during the rolling operation, or whether it would slip sideways toward the edge of the roll barrel in the first day of roll operation when the convexity is still pronounced. It was assumed that the spread of the rolled piece would take a different form owing to the introduction, as it were, of a spreading pass. Nothing of the kind, in fact, occurred.

With the use of experience acquired in the course of the operation of the first stand, the roll design was also changed at the first reversible roughing stand which had rolls with a flat barrel and 100 mm wide collars at the edges.

Owing to less stringent requirements with regard to the surface and shape of the rolled pieces received from the first stand, it is possible to confine the change of the rolls at this stand to the time of the full-day repairs of the blooming mill, i.e., every month and a half. In the course of this period, the middle part of the roll barrel is worn down by 20-25 mm (the barrel of the rolls of the first stand is longer than the part of the barrel for rolling slabs in the second stand and therefore the total wear of the rolls of the first stand is smaller). Such wear is very conducive to slant formation in the rolled pieces of the ratio $\frac{H}{B} \geq 1.3$ as it occurs when blooms are rolled and when the slabs are reduced in edging passes on a straight roll barrel.

To reduce the maximum variation in the distance between the rolls along the roll barrel in the course of the total life of the rolls, a change to a new design of rolls with a convexity of 10 mm in the middle of the barrel was made.

The rolling process proceeds quite normally with the convex rolls even during the initial period of operation.

To improve the operating conditions of the housing rollers and of the first rollers of the roller tables it became a practice at all blooming mills to make the diameter of the upper roll 10 mm smaller than the diameter of the lower roll. Under these conditions, the rolled piece should bend over the upper roll slightly and proceed smoothly onto the first rollers of the roller table. One can hardly consider this a desirable solution. Impacts on the rollers are dangerous during the initial period of ingot rolling when the rolled piece is of a large cross section. However, the difference of 10 mm in the roll diameter is not sufficient to bend the thick piece even a little. When the rolled piece is not uniformly heated, the bottom pressure does not prevent the ingot from bending toward the roller table if the ingot is unfavorably positioned.

On the other hand, as the cross-section area of the rolled piece decreases, the danger of shocks of the rolled pieces against the rollers decreases too, but the front end of the piece is bent upward more extensively owing to the lower pressure. Under the operating conditions which obtain at our blooming mill, this is not desirable.

The maximum opening of the shears used for cutting the front and the rear end of the rolled piece is about 350 mm. When 290 mm by 290 mm square blooms are rolled, the slightly upward-bent front end of the rolled piece cannot pass between the supports of the shears. For the rolled piece to be straightened it must be returned to the blooming mill and straightened by means of the manipulator. This entails stoppages in the blooming mill operation, cooling down of the rolled pieces and the appearance of defective ingots.

In view of the above facts, the difference in diameter between the upper and lower rolls was reduced by half i.e., to 5 mm. In this way, the bending of the front end of the rolled piece was completely eliminated.

As a test, rolls of the same diameter (without bottom pressure) were used for the whole period between the roll changes (15 days) and no difference was found between the rolls with and without bottom pressure in the course of the rolling process; the roller tables operated normally. This experiment proves that a steady operation with rolls of equal diameter is possible.

* * *

IMPROVEMENTS OF THE CONTINUOUS BILLET MILL

I.P. Shulaev and M.A. Vysotskii

Magnitogorsk Metallugical Combine

The continuous billet mill, which constitutes a part of the blooming mill, consists of six stands (Fig. 1) and is driven by a 5000 hp ac motor through a gear-reduction unit with bevel gears. In front of the first stand of the mill there are electric shears of 220 ton pressure, designed for cutting off the defective ends of the pieces entering the mill. Behind the sixth stand there are steam-driven flying shears for cutting the moving billets at a speed of 4 m/sec.

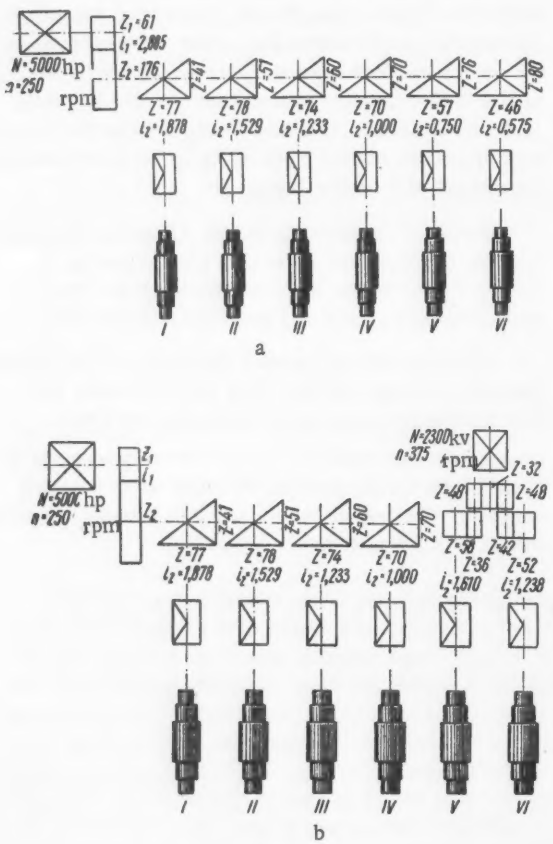


Fig. 1. Continuous billet mill. a) Before modernization; b) after modernization, I-VI stands.

Initially, the mill was used for rolling 60 mm by 60 mm square billets from 100 mm by 100 mm squares in four passes, the piece being delivered from the fourth stand; subsequently, a change was made to rolling billets from 120 mm by 120 mm square sections. At present, the mill produces square billets 58 by 58, 66 by 66, 78 by 78, and 97 by 97 mm (Fig. 2).

Improvement in the organization of production and a further improvement in the technological process could not ensure the necessary increase in the output of this mill with the existing equipment.

For this reason, the mill was modernized; at first, the gears in the main gear reduction unit were changed so that the number of revolutions of the rolls was increased by 13.1% and then by 21.2% as compared with the original design speed.

In order to prevent a reduction in mill output when dressed rolls were used (at the end of the service life of a set of rolls their wear amounts to 35-40 mm) the main reduction-gear-unit was provided with gears which increased the speed of the rolls by 28.4% as compared with the design speed.

A great part in the improvement of the technological process was played by the replacement of the helical guides for turning the rolled piece between the stands by tilting rollers of S.V. Merekin design, as well as by doubling the durability of the working rolls by using U15KhNM steel instead of U12 for their manufacture.

Since the bevel gears of the fifth and sixth stands were operating at a speed which was approaching the maximum speed and the flying shears could not be used for cutting a rolled piece moving at a speed higher than 4 m/sec, a further increase in the speed of rolling was made possible only by carrying out a radical modernization of the mill. A modernization plan, according to which all the work should be carried out during the annual four-day repairs, was adopted.

The first stage of the modernization included the introduction of a separate drive for the fifth and sixth stands, the second stage—the separation of the third and fourth stands from the common drive, the third stage—the introduction of a separate drive for the first and second stand (in this way the replacement of bevel gears by

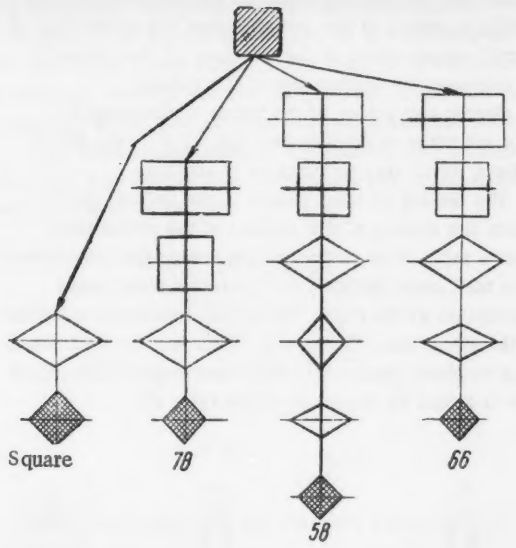


Fig. 2. Arrangement of passes for rolling square sections from 120 mm by 120 mm square billets on the continuous billet mill.

rectangular ones could be completed and the speed of rolling could be increased substantially), and the fourth stage—the replacement of all gear-unit stands and working stands by new ones. The object was to obtain a new fast continuous billet mill in place of the old mill, with rolls of larger diameter and with longer barrels which could accommodate a larger number of grooves.

For cutting the rolled pieces moving at a high speed (7 m/sec), it was planned to replace the steam-driven flying shears by electric planetary shears of 100-ton pressure designed by TsNIITMASh. In October, 1958, in accordance with the adopted modernization plan, the fifth and sixth stands were separated from the common drive and provided with one 2300 kw ac motor (see Fig. 1) at the time of the four-day repairs. The erection of a machine house for electric equipment and the installation of an electric motor were completed while the mill was in operation.

The new reduction-gear-unit of the fifth and sixth stands was mounted on a frame fastened by the foundation bolts of the old units; an apparatus designated for controlling the length of the end piece to be cut off the rolled section was installed between the sixth stand and the flying shears.

In December, 1958, the steam-driven flying shears were replaced by electric planetary shears and hence it was possible to provide the main gear unit of the mill with new gears which increased the speed of the rolls by 33.6% as compared with the design speed.

At the end of the modernization of the mill it was planned to increase the rolling speed of the 58 mm by 58 mm square billet in the sixth stand to 6.5 m/sec.

Owing to the modernization of the mill, it will now be possible to supply all small billets required by the rolling mills of the Combine and to establish conditions for a further increase in the production of wire and small-section steel.

However, the main disadvantage of the mill—the lack of adjustable drive—will still be there even after the modernization. In future, it will be desirable to provide the fourth, fifth and sixth stands with dc motors. It will then be possible to produce billets of new optimum dimensions and to increase the maneuverability of the mill.

* * *

RATIONAL ROLL ACCESSORIES FOR CONTINUOUS SECTION MILLS

B.V. Khovrin and V.V. Getmanets

"Krivorozhstal'" Factory

The highly efficient operation of the continuous mills, higher requirements regarding the quality of the product and the development of production created the need for better rolling equipment.

A study of the design of guides and guards at home and foreign mills has enabled the designers of our Factory to develop new guides and guards for wire and light-section mills at our Factory.

The wire mill consists of 39 stands arranged in eight continuous groups; the speed of rolling in the finishing stand is 28.3 m/sec.

The continuous light-section mill consists of 23 stands arranged in three groups; it is used for rolling round, square, and angle sections at a maximum speed of 14 m/sec in the finishing stand.

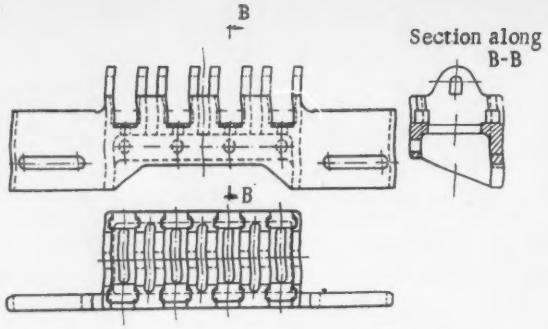


Fig. 1. Entry block of the roughing stand.

Roughing group. For the unification of the guides, one identical design of entry block for all the roughing stands was developed and introduced. The entry block (Fig. 1) is made in such a way that the guides are set directly in its interconnected seats. The number of seats corresponds to the number of pieces rolled at the same time in the roughing group. Two-strand rolling is employed in this group on the small-section mill, and four-strand rolling on the wire mill. When a change to a new pass arrangement is made, the entry block is moved by a simple screw mechanism with a predetermined arrangement of the passes. The block can be adjusted in its vertical position by means of screw jacks.

The delivery blocks of the roughing group are of the same design for all stands and consist of a housing (Fig. 2) inside which guides are placed according to the pass arrangement. The delivery block is stationary. When the passes are changed, the guides are adjusted inside the housing. When the stand is adjusted on the mill, the block is aligned by means of jacks.

The introduction of blocks of the new design made it possible to reduce stoppages for the change of passes and to simplify the adjustment of the guides.

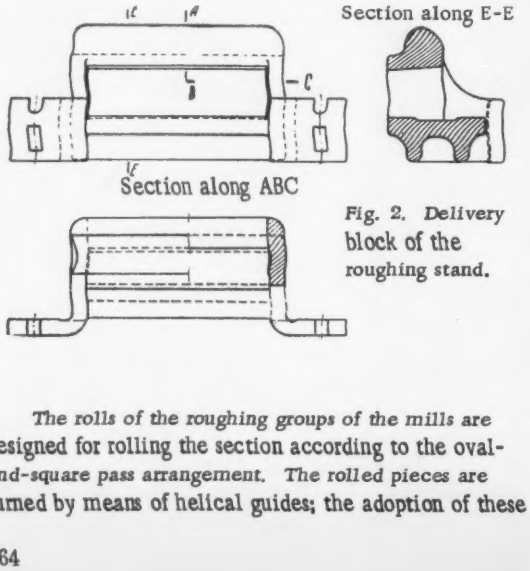


Fig. 2. Delivery block of the roughing stand.

The rolls of the roughing groups of the mills are designed for rolling the section according to the oval-and-square pass arrangement. The rolled pieces are turned by means of helical guides; the adoption of these guides, with the turning angle calculated according to formula accepted at the works, makes the adjustment of the mill easier owing to the accuracy of the operation and increases the service life of the guides.

Guards and guides of the stands of the roughing group are made of 35-502 steel (GOST 977-41) which has been found very satisfactory in service.

The turning of large pieces in the helical guides impairs the quality of the surface of the rolled steel, causes a rapid wear of the guides, makes the adjustment of the mill more difficult and increases total power consumption at the mill. Therefore, between the second and the third, and between the fourth and the fifth stands of the roughing group of the light-section mill the rolled piece is turned by means of rollers (Fig. 3).

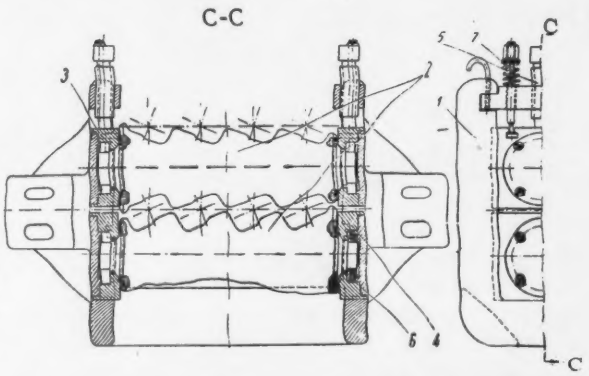


Fig. 3. Diagram showing the position of turning rollers: 1) Housing; 2) turning rollers; 3), 4) bearing chock; 5) screw-down pressure screw; 6) roller bearing; 7) counter-balancing (spring) attachment of the upper roller.

The turning rollers are made from low-alloy worn-out rolls. The grooves of the turning rollers are sized according to the dimensions of the turned piece and are arranged according to the layout of the passes of the working roll. The turning rollers completely eliminate all the disadvantages of the helical guides.

Finishing group. It is usually very difficult to assure a reliable entry of the oval piece into the next pass when the finishing stands of the mill are adjusted.

As a rule, when round section is rolled, the entry guides for oval piece are fairly long and have very small clearance between the surface of the rolled piece and the working surface of the guide. This causes large frictional forces and a rapid wear of the guides and the adhesion of steel and scale on the working surface of the guides; it also affects the quality of the surface of the finished product.

Using the experience gained in the operation of the mills, the roll design office at our Factory developed a method of calculating the working part of the oval guides for some arrangements of passes for rolling round sections. The calculation of the dimensions of the

surface area of the guide is based on the design dimensions of the preceding pass and on the assumption that the rolled piece should move freely in the guides. In addition, specific features of the wear of the oval pass depending on the pass arrangement are taken into account.

The design dimensions of the working part of the pass (Fig. 4,a) for the oval-and-square pass arrangement are calculated as follows:

$$A = (1{,}15 - 1{,}3)h;$$
$$R_k = R_n$$
$$B = 2\sqrt{A \cdot R_n - \left(\frac{A}{2}\right)^2};$$
$$K = B + (0{,}5 - 1{,}0)\,h;$$
$$S = 2t,$$

where R_k is the radius of the oval pass according to the design;

R_n is the radius of the working surface of the guide.

For the oval-and-edging oval pass arrangement, the dimensions of the working surface of the guide (Fig. 4,b) are determined as follows:

$$(A = 1{,}15 - 1{,}3)\,h;$$
$$B = b_k;$$
$$R_n = \frac{A^2 + B^2}{4A};$$
$$K = B + (0{,}5 - 1{,}0)\,h;$$
$$S = 2t,$$

where b_k is the design width of the oval section according to the pass design.

By using guides designed by the above method, it was possible to reduce the stoppages required for the adjustment of the mill and to improve the quality of the surface of the finished product.

For entering the oval and the diamond sections into the finishing stand of the light-section mill, roller guides are used.

In the design shown in Fig. 5, the guides (4) are set up in the box (1) which contains two roller holders (2), on movable axles, with grooved rolls (3) made of 65G steel.

The box is aligned with respect to the pass and mounted in the housing (5). The position of the rolls in the vertical direction is adjusted by means of threaded movable axles (6). The clearance between the rollers is adjusted by means of the screws (7), so that it is possible to roll a number of round sections using the same roller housing. The bearings (8) of the rollers are lubricated through the holes in the center of their axles by means of oil from a central lubrication system.

When angle sections are rolled, the finishing stand of the light-section mill is provided with an entering roller housing (Fig. 6)

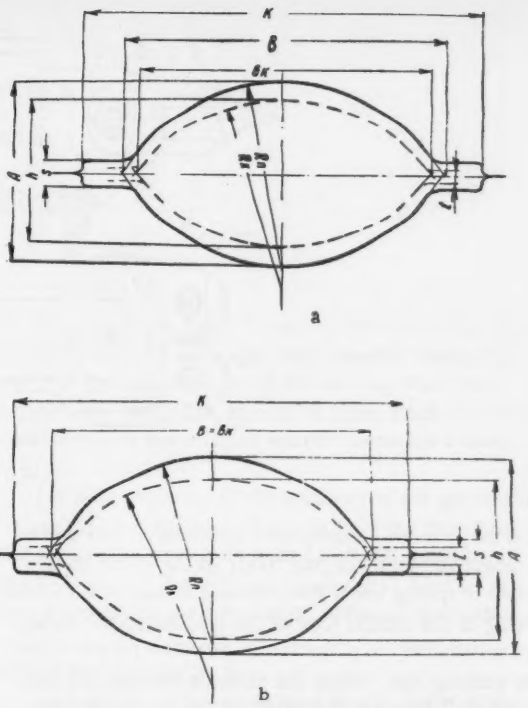


Fig. 4. The working part of the oval pass for the pass arrangement; a) Oval-and-square; b) oval-and-edging oval.

The body of the housing is rigidly fixed on a block. The front end of the body is elongated and made in the form of a fork in which the lower roller is mounted. The upper roller is mounted in a stirrup and its height is determined by the fixing screw. The rollers are made of 30KhGSA steel, hardened to 500-550 H_B. The rollers rotate on conical roller bearings around stationary axles which have a lubrication duct in their center. The upper roller is maintained in the extreme lower position by means of a weight suspended on a hook. Free guides with funnel shaped ends and mounted in housing body are provided for entering the piece between the rollers.

The entering equipment described here has a particular design feature — the displacement of the axles of the lower and upper rollers in the course of the rolling operation and, in addition, the counterweights for the upper roller*.

In the design of the roller guides (Fig. 5) used for entering the oval piece into the finishing stand of the wire mill, the specific features of the operation of that mill were take into account.

The free guide pieces of the guide are elongated and are fixed in the housing by means of four bolts so

*Designed by V. V. Ostapenko and B. V. Khovrin. The inventors of the entering roller housing were awarded prizes in the competition of the Ukrainian State Scientific and Technical Society of Ferrous Metallurgy.

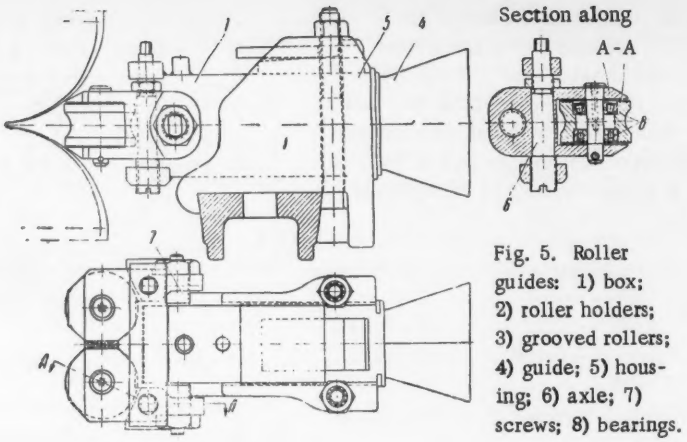


Fig. 5. Roller guides: 1) box; 2) roller holders; 3) grooved rollers; 4) guide; 5) housing; 6) axle; 7) screws; 8) bearings.

that they can be adjusted very accurately. The end of a defective piece can pass freely owing to the installation of springs under the adjusting screws of the rollers. Owing to the central feed of the lubricating oil through the roll-holder body, the rollers could be placed nearer the working pass. Since the distance between the axis of the mill rolls and the guide rollers was made very small, a reliable entry of the oval piece into the circular groove was ensured. The roller surface is sprayed with water fed through a stationary tube.

Owing to the adoption of entering roller housing, a free and easy movement of the front end of the rolled piece, regardless of its defects toward the mill rolls, is achieved; the rolled piece is maintained in a stable position and prevented from being misaligned or twisted; the adjustment of the mill is made convenient and simple; the service life of the entering guides is made longer and the quality of the finished product improved.

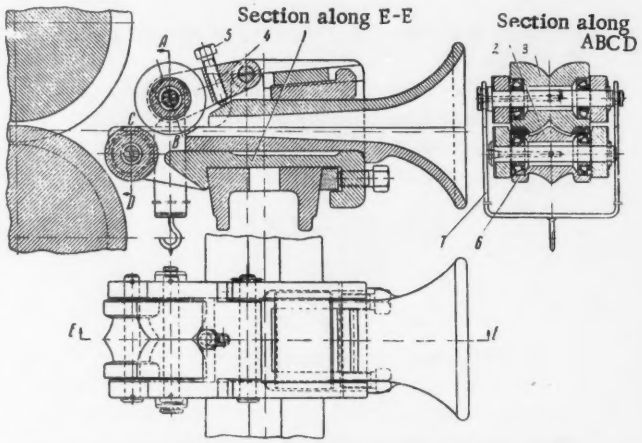


Fig. 6. Entering roller guide: 1) Body; 2) lower roller; 3) upper roller; 4) stirrup; 5) adjusting screw; 6) roller bearings; 7) hook.

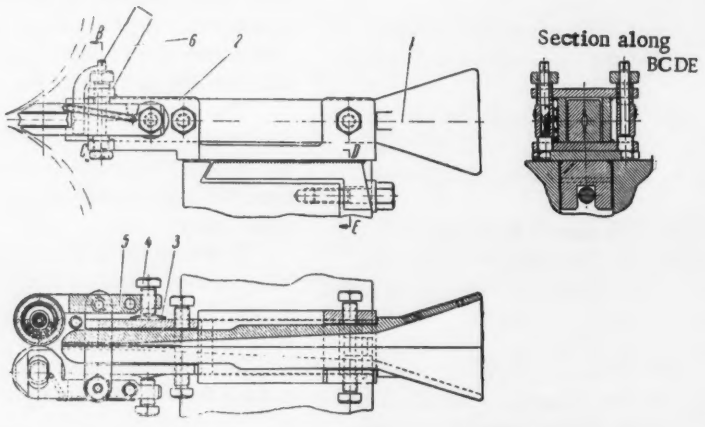


Fig. 7. Roller guide of the wire mill: 1) Guide; 2) housing; 3) springs; 4) adjusting bolts; 5) roller holder; 6) water tube.

A DESIGN OF PIERCING-MILL ROLLS WITH A MINIMUM ANGLE OF THE DELIVERY CONE

V.Ya. Ostrenko, P.I. Vatutin, E.I. Ulinskaya, and N.S. Kirvalidze

Ukrainian ScientificTube Research Institute

In 1957, on the suggestion of P.I. Vatutin and V.Ya. Ostrenko, a new roll design with a minimum angle of the delivery cone (1°) was introduced at the rotary piercing mill of the automatic tube mill of the Yuzhnotrubnoi Factory; previously, rolls with a 3° 30' angle of the delivery cone were used.

New guides were designed in conformity with the changed contour of the rolls, and new mandrels for each size of tube were calculated on the basis of the direct relationship between the length of the mandrel and its diameter (Fig. 1).

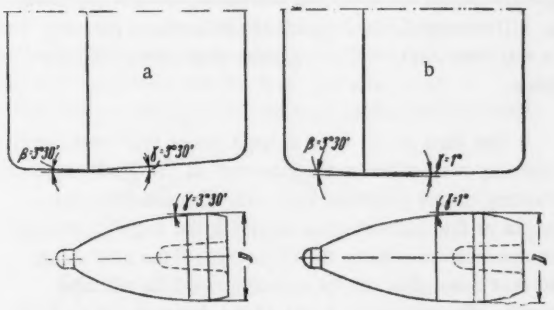


Fig. 1. Section through the working rolls and mandrels; a) Design in use; b) new design.

Preliminary tests on the new roll design showed that it has several advantages over the design which is used now. The main advantage is an improvement in the surface of the tube.

To obtain more extensive data on the advantages and disadvantages of both types of roll design, special tests were carried out at the Yuzhnotrubnoi Factory. The following tube sizes were selected for the tests (a set of mandrels and guides for both sections were available at the mill during the rolling): 108×4.25 and 127×4.5 mm of MSt. D steel, and 63.5×10.5 mm MShKh15 steel.

Table 1 shows the dimensions of tube, initial billets and shells, and data on the adjustments and conditions of operation of the piercing mill.

Table 2 gives the results of the primary inspection of the finished tubes of the experimental batches (108×4.25 and 127×4.5 mm) as reported by the OTK (Department of Technical Control) of the tube-rolling mill.

It is seen from Table 2 that for both tube sizes the quality of the tube surface is much superior when rolls with a 1° inclination angle of the delivery cone (new design) were used. The amount of tubes which required conditioning of the external surface decreased almost by half.

For the evaluation of the accuracy of the geometrical dimensions, the thickness of the walls of the front and rear end of 100 tubes from each batch was measured. The thickness of the wall was measured at 8 points and from these results the distribution curves of thickness variation of the front and rear end of the tubes were plotted as shown in Fig. 2.

An analysis of these graphs shows that there is no significant difference in the accuracy of tube dimensions, although for the front end of 127×4.5 mm tubes rolled with rolls of 1° inclination angle there is a slight displacement of the maximum of the curve to the left.

In all cases when billets were pierced with the use of rolls with a 1° angle of the delivery cone, the axial force was considerably lower (by 15-25%) than for the piercing of tubes with the use of rolls with a 3° 30' inclination angle of the delivery cone.

The actual speed of piercing with the use of 1° rolls was higher than the speed of piercing with the use of 3° 30' rolls.

The slip coefficient in all experiments was found to be higher in the case of 1° rolls, by 5% for 108×4.25 mm mm tubes; by 12% for 63.5×10.5 mm tubes and by 26% for 127×4.5 mm tubes. This indicates that better kinematic conditions for piercing the billets are obtained when rolls of a minimum angle of the delivery cone are used.

When the billets are pierced with the use of rolls with a 1° inclination angle the force is 3.5% lower and the power consumption 26% lower than in the case of rolls with a 3° 30' inclination angle for 108×4.25 mm tubes; for 65.3×10.5 mm tubes, the force is higher by 29% and the power consumption is approximately the same; for 127×4.5 mm tubes, the force is 26% higher and the power consumption is approximately the same.

The increase in the force when 63.5×10.5 mm and 127×4.5 mm tubes were rolled with the use of rolls with a 1° inclination angle was due to the higher speed of piercing. At the same time, it is significant that for 63.5×10.5 mm tubes the specific power consumption

TABLE 1

Data on the Dimensions of Tubes, Billets and Tube Shells, and on the Mill Adjustments

Design	Roll diameter, mm	Tube size, mm	Billet size		Steel grade	Shell size, mm	Draft coefficient	Inclination angle of the rolls, degrees	Roll speed, rpm	Reduction		Mandrel diameter, mm	Mandrel holder, mm	Steel temperature during piercing, °C
			diameter, mm	length, m						mm	%			
Now in use. .	712	108×4 25	110	1.2	D	110×7,5×4730	4.12	10	115	17	15.5	92	64	1210
New.	644		110	1.2	D	109×8×4450	3.28	10	133	12	10.9	92	34	1213
Now in use. .	709	63,5×10 5	90	3.4	ShKh15	95×12×6525	1.91	10	78	11	12.2	64	35	1085
New.	644		90	2.7	ShKh15	94×11×5730	2.1	10	103	7	7.8	64	35	1105
Now in use. .	708	127×4 5	130	1.2	D	133×8×4700	3.91	10	96	17	13	110	80	1219
New.	770		130	1.2	D	131×8×4950	4.17	10	94	14	10.8	110	30	1222

TABLE 2

Results of the Primary Inspection of Tubes from the Experimental Batches

Roll design	Tube size, mm	Heat Number	Number of tubes inspected	Tubes requiring conditioning	
				No.	%
Now in use. . .	108×4,25	12693	471	293	62
New.		12693	557	193	35
Now in use . .	127×4,5	15504	251	196	78
New.		15504	264	120	45

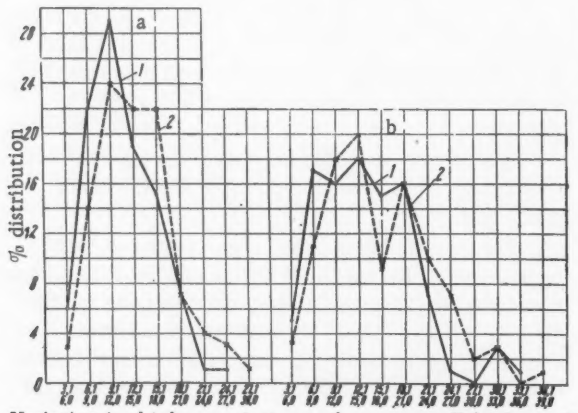


Fig. 2. Distribution curves of tube wall thickness variation of 172 × 4.5 mm tubes: a) Front end; b) rear end; 1) rolls of 1° inclination angle; 2) rolls of 3°30' inclination angle.

(in kw-hr/ton) was found to be almost the same for both cases (28.25 kw-hr/ton for a 3° 30' inclination angle and 28.65 kw-hr/ton for a 1° inclination angle), in spite of the fact that in the second case the billets were almost half as long (for the same diameter of the billet, the specific power consumption increases with the decrease in billet length). It means that the speed of piercing in this case increased to a greater degree than did the force.

The tests which were carried out at the convex-roll piercing mill of the automatic mill at the Yuzhnotrubnoi Factory on the piercing-mill rolls with the minimum angle of the delivery cone and with the angle at present in use showed clearly the advantages of the new design so that these rolls can be recommended for all tube works. The minimum angle of the delivery cone of the rolls is determined in each individual case by the roll dimensions which are required to obtain the desired geometrical dimensions of the shell. The minimum angle of the delivery cone for the piercing mill of the automatic tube mill of the Yuzhnotrubnoi Factory, where the tests were carried out, is 1°

Editor's note. The question of a general introduction of this method of roll design should be decided after a great many tests have been carried out to show the advantages and disadvantages of this design.

PIERCING THE HOLES IN RAIL-JOINT BARS

G.P. Efimov

Kuznetsk Metallurgical Combine

Composite milling cutter. When holes are punched in rail-joint bars, burrs are formed which are then removed on dressing machines with the use of mill cutters made of R18 or 9KhS steel. With a view to saving expensive steel, the Kuznetsk Metallurgical Combine tested composite cutters which were found to be very durable (up to 500,000 rail-joint bars can be dressed by one cutter).

The composite cutter (Fig. 1) is made of MSt.3 steel and has a built up working layer of R18 steel. The cutter disc is forged from MSt.3 steel. It is then machined on a lathe, then the cotter groove is cut out and a layer is built up by welding with the use of a good-quality electrode. The working surface of the disc is covered with a layer of R18 steel by means of a continuous welding, the disc being heated beforehand to 200° C. Immediately afterward the disc is annealed according to the method applied to R18 steel, the teeth are milled, the cotter groove is machined and the final heat treatment is carried out according to the method applied to R18 steel.

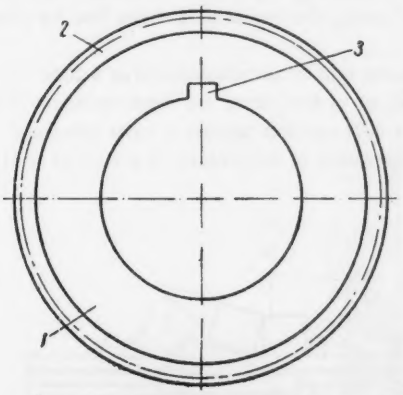


Fig. 1. Composite cutter: 1) disc; 2) built-up layer; 3) cotter groove.

The electrodes of R18 steel for the built-up layer on the cutter are made in the form of rods 3-5 mm in diameter and 350-400 mm long drawn from waste material of the same steel. The composition of the lubricant is: chalk – 50%; fluorspar – 32% graphite – 3%; ferrotitanium – 15%.

Reconditioning punches for punching rectangular holes in rail-joint bar. At the Kuznetsk Metallurgical Combine the holes in the rail-joint bars are made by means of punches made from the 5KhV2S steel supplied in rods 32 mm in diameter and 3-3.5 m long (Fig. 2).

These rods are cut into uniform pieces, 100-125 mm long. The working end of the punch is forged over the length of 50 mm according to a pattern, after the punch has been heated in the hearth. Then, after it has been heated again, the upper head is formed in a die, the punch is heated to 800°C and annealed; it is then centered in a special device, the cylindrical part of the head is machined on a lathe and the working part is machined on a milling machine. After it has been sized on the

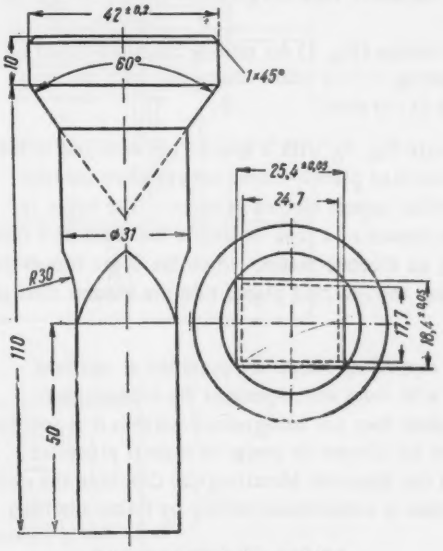


Fig. 2. Punch for making holes in the big flange of R-43, R-50 and R-65 rail-joint bars.

lathe, the punch is quenched at 920°C in oil, tempered at 260°C in an electric furnace in the course of 1 hour and 30 minutes, and finally the working part is ground to the required pattern.

Because of the high cost of the steel and the involved process of making the punches, it is desirable to recondition them by restoring the worn working part. It is important to stop using the punch in goodtime, to prepare it for reconditioning.

The reconditioning of a worn punch is carried out in the following sequence: high tempering (550-600°C) for two hours, upsetting and forging the working part under a hammer, final dressing of the working part (by hand) according to a pattern after the punch has been heated again, normalizing (840-860 °C) and cooling to 500 °C, final heat treatment (quenching and tempering) according to the method described above and grinding the working part.

The forging operations in making new punches involve approximately as much labor as does reconditioning. However, the total time required for the reconditioning is less than for making a new punch. In addition, savings in steel are effected.

Tests have shown that the durability of a reconditioned punch is not inferior to that of a new one. A punch can be reconditioned four times until its length is reduced to the minimum (102 mm).

* * *

MACHINE FOR TURNING BLOOMS AT THE BILLET STORE

A.V. Babushkin

Kuznetsk Metallurgical Combine

A machine (Fig. 1) for turning blooms of 1300 kg weight during surface conditioning has been put into operation at our shop.

A bogie Fig. 2), with a special top arranged in the form of inclined planes, moves between two parallel beams which support blooms or ingots. The bogie is moved by means of a rope wound on the drum of a hoist driven by an electric motor. When the bogie moves under the blooms, the inclined planes turn the blooms through 90°.

The supporting beams are provided at uniform intervals with stops which prevent the blooms from shifting when they are being turned and thus it is possible to remove the blooms in groups of several pieces at a time. At the Kuznetsk Metallurgical Combine the surface of the billets is conditioned mainly by flame scarfing; during the scarfing a large amount of slag falls into the steel sheet-lined trough under the machine. The bogie is provided with a scraper; when the bogie is returned to the initial position after turning the blooms, the scraper pushes the slag into a container at the bottom of a special pit.

The machine is operated by means of a button positioned in the middle of the machine and interlinked with an electric warning bell which rings before the machine is operated.

When two returning bogies were installed, eight men employed on turning the ingots were made free for other duties

Sixty blooms can be accommodated at a time on each machine; up to 400 pieces are conditioned on two machines in a shift and this number is quite adequate for efficient operation of the furnace of the billet mill.

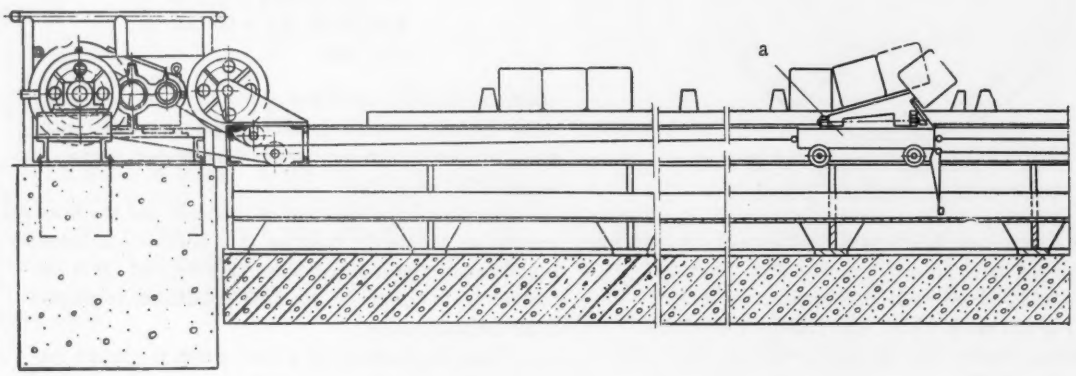
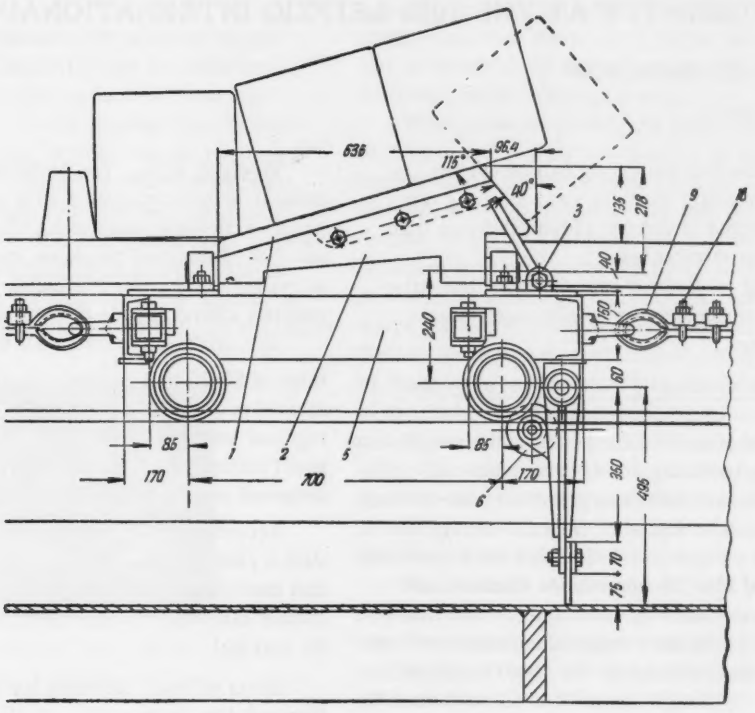


Fig. 1. Arrangement for turning the blooms: a) Bogie.



Side view

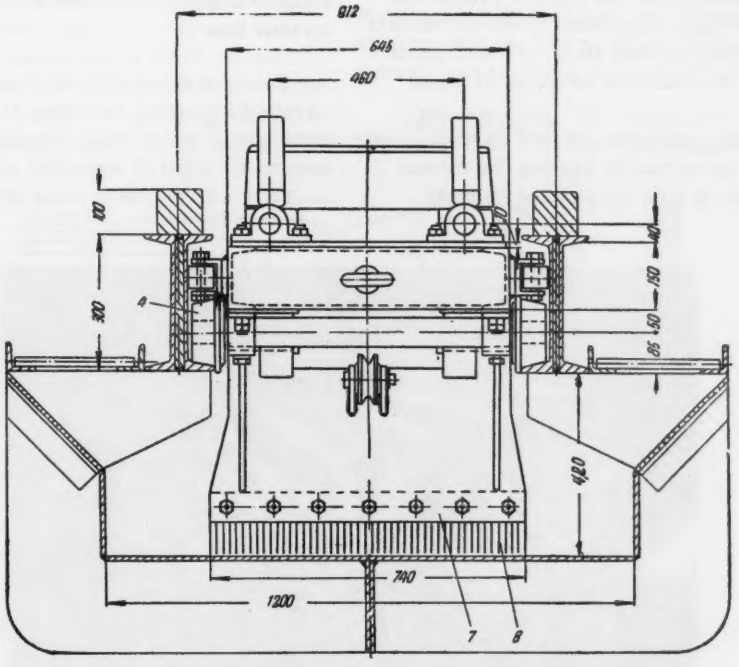


Fig. 2. Bogie for turning the blooms: 1) Rail; 2) lever; 3) fixing pin; 4) roller; 5) frame; 6) pulley; 7) scraper; 8) rope; 9) eye; 10) clamp.

Metallurgy Abroad

THE TUBE INDUSTRY AT THE 1958 LEIPZIG INTERNATIONAL FAIR

Yu.N. Kozhevnikov

GNTK RSFSR

The 1958 International Spring Fair at Leipzig in the German Democratic Republic was a very big fair at which all branches of industry (9600 exhibitors from 43 countries) were represented.

We are going to describe here the most interesting types of tubular products shown by some well-known western companies.

Thick-wall centrifugally cast tubes of alloy steel. The West-German firm, "Deutscheedelstahlwerke", exhibited samples of thick-walled tubes and some products made from them, including double-wall tubes cast centrifugally and made from every possible heat-resistant and acid-resistant steel and alloy (Fig. 1). During the past 25 years this company in Bochum has been producing cast steel tubes of 100-735 mm outside diameter and 5000 mm length in horizontal machines (70 mm inside diameter). Most of the tubes supplied are machined and polished outside and inside but on the client's request the tubes can by supplied in an unfinished condition with a dressed internal surface.

The double-walled tubes are made of carbon-steel in combination with high-alloy steels which are resistant to corrosion, with heat-resistant steels, and with steels which are suitable for operations involving frictional wear.

The centrifugally cast tubes are used for shaft jackets for the furnace rollers in heating furnaces, for cement conveyance, for rolls in glass industry and for other purposes.

Precision tubes. The "Schöller" firm (Federal German Republic)showed a wide assortment of round and special-shape tubes of 0.1-20 mm outside diameter and 0.01-3 mm wall thickness made of carbon and high-alloy steels and alloys (including heat-resistant and stainless alloys) as well as of various nonferrous metals.

The initial material for all the tubes is cold rolled tubes of 20-25 mm outside diameter which are converted into tubes of the required size by means of repeated drawings and intermediate treatment in electric vacuum furnaces (vacuum of 10^{-3}) and are supplied either quenched or tempered and with a smooth, lustrous surface.

According to this firm, the thickness of the tube wall is predetermined by long mandrels (wires) of 0.8-1 mm minimum diameter. In the production of tubes of smaller diameter, the subsequent drawing is done without the mandrel.

Tubes of small diameter are made with the use of diamond dies which ensure a high quality of the outer surface of the finished tubes. Tubes of a diameter larger than 2-3 mm are drawn with the use of hard alloy and ceramic dies.

For the removal of mandrels, the tubes are rolled on roll-straightening machines, and tubes of small diameter are rolled on small two-high mills with straight-body rolls. Tubes of very small dimensions are drawn manually with the use of pliers for pulling their tapered ends.

Fig. 1. Centrifugally cast thick-wall steel tubes.

The tubes are designated for medical syringes, oil and petrol lines, chemical, refrigeration, radio, and instrument industries, etc.

A very interesting feature is the adoption by this firm (in the town of Hellenthal) of the hot diffusion plating of external and internal surfaces of tubes with chromium to a depth of 100-150 microns (Fig. 2), the process being carried out in vertical electric resistance furnaces. The tubes are resistant to corrosion and heat. They stand up well to acids, they are heat resistant at temperatures up to 850 °C and can replace steel of 30% chromium content. When they are hot, their ultimate tensile strength is within the range of 35-40 kg/mm^2 at 25-30% elongation. Tubes produced in this way are easily machined when cold.

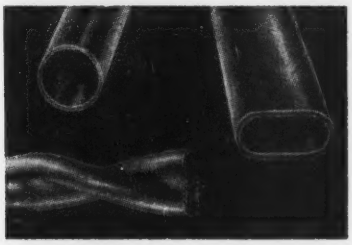


Fig. 2. Specimens of tubes plated with chromium by means of diffusion plating.

Double-wall welded tubes. The "Meccano-Bandi" firm (Heidelberg) showed double-wall copper-clad and zinc-clad thin-wall welded tubes of 2-10 mm od and 0.75-1.0 mm wall thickness (Figure 3) which are used extensively in the Federal German Republic in the Transport-machinery industry (tubing for fuel, compressed air, and for braking mechanisms); in the electric industry (for cooling coils, cooling equipment of air heaters, aerial guides, cable sheathing, etc.), in the machine industry (for lubricant tubes, compressed air ducts, gas holder tubes, fuse tubes, etc.), in the instrument industry (for air-conditioning equipment, condensers, tube and overhead heaters, spray guns etc.).

These tubes are made from steel strip covered on both sides with a layer of copper by an electrolytic method on a continuous multi-stand mill with specially designed rolls. On this mill, the strip is shaped into a double-wall tube; then the tubes in which both layers (walls) of the strip adhere tightly to each other are heated in a continuous electric furnace in an inert gas atmosphere where the copper melts and a strong welding bond between the two metal layers is established. The tubes are tested by means of special electronic equipment in the course of the production process (nondestructive testing).

Figure 4 shows (magnified) the place in the tube where the strip overlaps and where the separate layers of the steel tube welded to each other are clearly seen as also is the penetration of the copper between the grain boundary of the metal of the steel wall.

For a reliable transmission of high pressure, for resistance to twisting when car industry equipment is installed, and especially for a reliable functioning of braking equipment, the "Meccano-Bandi" Factory produces "double-end" tubes (Fig. 5).

The tubes made by "Meccano-Bandi" are elastic and flexible, and can be tightened easily; they do not scale, are easily machined, end-formed and welded; they are distinguished by a high tensile and bending strength, and few stand up to a high temperature well.

Cast-iron tubes. The "Giessrohre" firm (Gelsenkirchem) showed high-strength corrosion resistant cast iron tubes

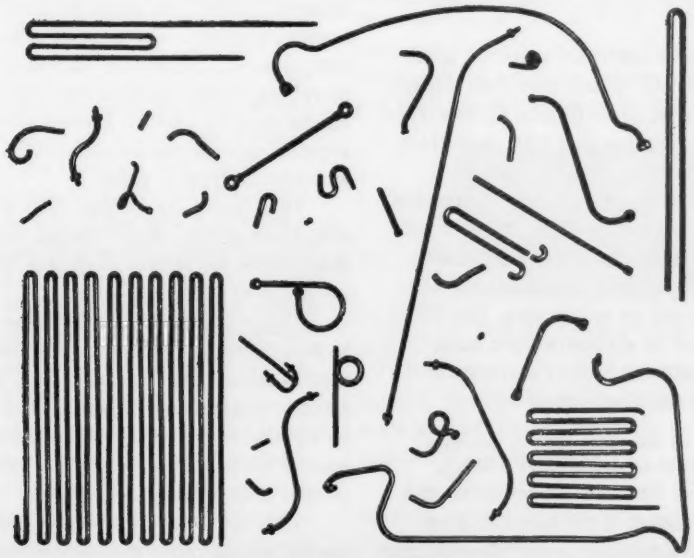


Fig. 3. Products of double-wall welded tubes.

made by means of modern centrifugal and semicontinuous methods.

The tubes are cast centrifugally in water-cooled molds, 125-600 mm wide and up to 6 m long by means of machines, and in hot removable molds, 550 to 125-150 mm wide and 3-5 m long on a conveyor-type machine.

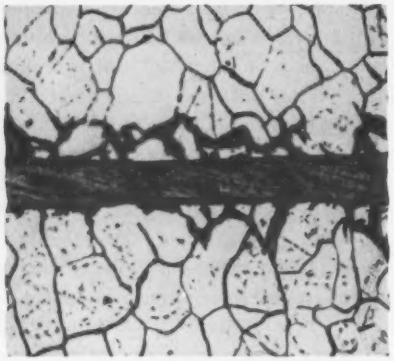


Fig. 4. Microsection of the weld between the walls of a double-wall tube.

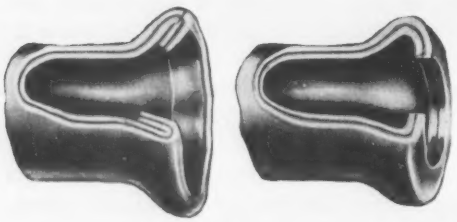


Fig. 5. "Double end" of welded tubes.

Cast iron tubes of 300-900 mm diameter and up to 9 m long are made by means of a semicontinuous method; it is planned to cast tubes of up to 1500 mm od and 10 m in length.

This firm also showed water-main cast-iron tubes cut longitudinally into sections which were bent through 180° in the same way as steel tubes (Figure 6); this indicates the high quality of the tubes cast from iron which contains nodular graphite.

For the "Gewerkschaft-Reuss" firm, the "Giessrohre" firm produces double-wall tubes for the pneumatic and hydraulic conveyance of stone into worked-out shafts in the mining industry. Specimens of these tubes, 150 and 175 mm in diameter and up to 4 m long, had a 3 m thick external wall formed by electro-welded tubes from mild steel, and an internal wall of cast iron of 500-600 Brinell hardness and 10 mm thick.

The internal surface of the steel tube is covered by liquid cast iron by means of centrifugal casting. The cast iron layer adheres well to the steel tube. The internal, harder, cast-iron layer of the tube stands up well to attrition and lasts, according to the "Gewerkschaft-Reuss" firm 2-3 times as long as ordinary steel tube.

These tubes are used for conveying abrasive loose materials such as rock, cement, sand, slag, coal dust and other materials.

Special-shape tubing. The "Mannesman" firm exhibited a wide assortment of all kinds of special shaped

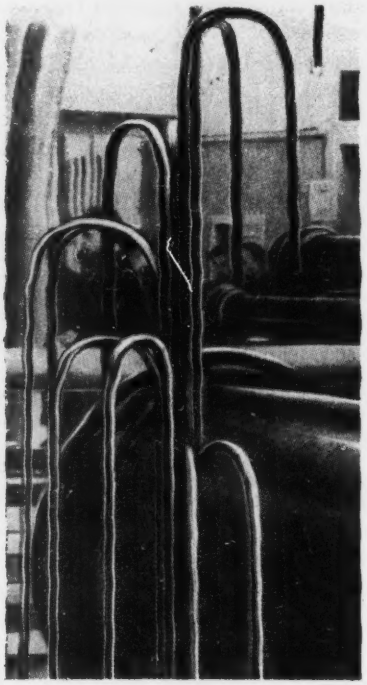


Fig. 6. Cold cut and bent pieces of cast-iron tube cast by the centrifugal method.

tubes (Figure 7) made of carbon and alloy steels.

Tubes with external and internal fins, star-shaped and helical, used in chemical equipment, condensers, recuperators, driers and heat exchangers, are of special interest. Tubes with rolled external helical grooves ensure excellent heat transfer, especially at high temperatures. Tubes with star-shaped surface, formed by rolling, have a smaller heat transfer surface but they can be used for parallel streams whereas tubes with rolled external grooves can be used only for cross flow or cross-and-counter flow of gases.

To increase the internal heat transfer surface, tubes with internal fins, whose internal surface area is more than double the surface of smooth tubes, are used. They are made at cold-rolling mills.

Twisted tubes (Figure 8), made by the Tube Factory in Riza (German Democratic Republic), are extensively used in driers. On account of their shape, the tubes assist in mixing loose materials subjected to drying, and on account of the rotary motion they throw the material against the heated surface of the tube so that the drying process is speeded up.

They are made by means of drawing through a special shaped spiral die. A special rotary gripping attachment (Fig. 9) is used for pulling the tube end.

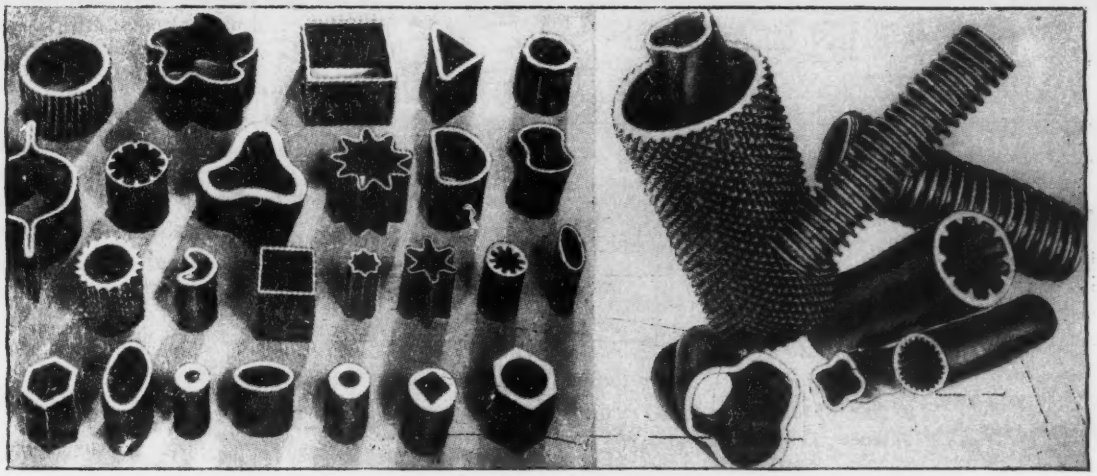


Fig. 7. Special shaped tubes made by the "Mannesman" firm.

Finned and twisted tubes can be supplied in any size; the remaining special shaped tubes are made in sizes from 30-100 mm od. The grooved and wavy tubes with an extended surface (up to 2.8 times the surface of an equivalent length of smooth tube) are also made from heat-resistant steels. According to the "Mannesman" firm a substantial increase in tube surface has been achieved only for carbon steels so far. For austenitic steel the maximum depth of the groove can be 4 mm.

Corrosion protection of steel tubes. The "Fenix-Reinrohr" and "Mannesman" firms (Federal German Republic) have been supplying gas-main and water-main steel tubes protected by anti-corrosive bituminous coatings for many years.

For better protection, tubes which are laid into highly corrosive soil are wrapped with a special strip. Various materials which are used for sheathing combine with the bituminous coating and enhance resistance to the mechanical action of soil.

The following method of covering the tubes is used by those firms: first, the tubes are coated with a bituminous layer in a bath of hot bitumen; they are then wrapped with strips which pass through a hot insulating mixture, and hence the surface of the tube is covered with a layer of this mixture (Figure 10). Next, the strip is smoothed out to make sure that the insulation adheres tightly to the surface of the tube. For protection against the sun and to prevent the tubes from sticking together during storage and transportation, the tubes are coated with lime or sprayed and rubbed with talc.

Previously, cardboard or organic-tissue strips treated with preservatives for protection against moisture and decay were used; now, glass fiber or glass wool are used almost exclusively for sheathing the protective coating. The glass-fiber strips are usually treated beforehand with bituminous mixtures which contain antiseptics for preventing microbiological processes. The glass-fiber strips do not decay and, unlike the organic tissue, do not conduct moisture by capillary forces.

According to the information given by these firms, the glass-fiber strip, when passed through the hot liquid insulation mixture, is instantaneously saturated and then wrapped around the tube. The air or vapor bubbles carried out of the liquid bath are easily pressed out through the permeable strip. When wrapped around the pipe the strip overlaps and lies evenly in the insulation coating.

A double coating is applied if there are difficult conditions in transportation and tube laying.

The main types of insulation coating which are used in the Federal German Republic for the protection of water mains against corrosion are coatings with bituminous bases as well as coal tar bases. Bitumens without fillers show a tendency to water absorption. The coal-tar coatings show a smaller tendency to water absorption and their water content remains almost constant.

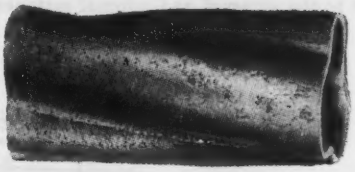


Fig. 8. Twisted tubes for driers.

Sometimes, it is more economic to lay the tubes in sand. Both firms maintain that laying the coated tubes in sand is most justifiable in corrosive clay, sedimentation and stony soils.

The firms can supply tubes with internal bituminous coating, as well as tubes with a thin coating applied on the internal surface of the tube by means of immersion in a hot bituminous bath or by means of painting with a tested bituminous paint.

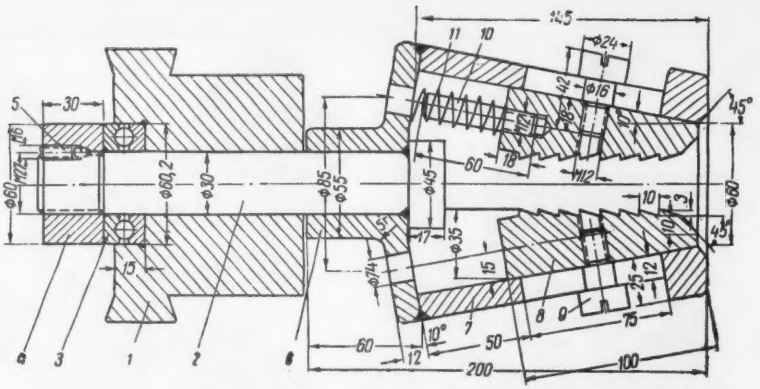


Fig. 9. Gripping attachment for drawing twisted tubes: 1) Mounting; 2) bolt; 3) roller bearing; 4) ring; 5) pin; 6) flange; 7) chuck; 8) jaw; 9) screw; 10) bolt; 11) spring.

For the insulation of tube junctions and the adjoining bare sections as well as screwed joints the firms supply, with the tubes, a special bituminous adhesive (bituplast) which is applied to the bare sections and screw joints in the field where the tubes are laid. At the Riza Works in the German Democratic Republic, all tubes which are laid in soil, including tubes imported from the Soviet Union, are covered with bituminous coatings. For this

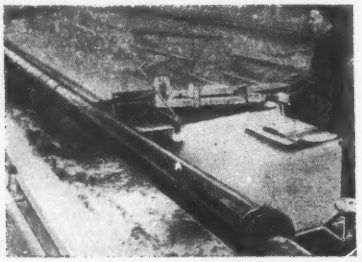


Fig. 10. Covering the tube with reinforced bituminous coating.

purpose, a special section with vessels for heating the bitumen, two machines (Figure 11) for applying a thin bitumen coat to the external and internal surfaces of tubes (by immersion in hot liquid bitumen after preliminary heating) and with three machines for applying bituminous coating to the external tube surface by means of a strip was set up at the tube rolling shop. Two of these machines are intended for 18-159 mm diameter tubes; one of them has two stands for laying strip on the tube covered with bitumen, a recovering automatic carriage with a liquid-bitumen bath and a reel with the strip; the other machine has one stand for laying the strip and one nonrevolving automatic carriage. A third machine of a similar type is used for coating 400-500 mm diameter tubes.

At the two-stand machine there are eight men per shift, including five men operating the two stands. They coat up to 500 tubes of 50 mm diameter per shift. On the single-stand machine there are six men per shift, including 4 men operating the stand. Up to 300 tubes of 108 mm diameter are coated at this stand per shift. At the large machine, up to 20 tubes of 500 mm diameter and up to 32 tubes of 400 mm diameter are coated per shift.

Tubes of up to 150 mm diameter are coated with a layer up to 3 mm thick, and tubes of 400-500 mm diameter—with a layer up to 5 mm thick. Cotton strip,

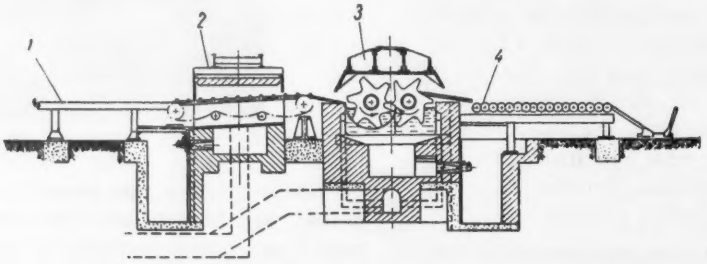


Fig. 11. Diagram of the machine for coating the external and internal tube surface with liquid bitumen: 1) receiving table; 2) furnace for heating the tubes; 3) heated both with liquid bitumen; 4) table for tubes covered with bitumen.

in rolls from 50 to 100 mm wide and up to 100 mm long, soaked with a special antidecay substance is used for anticorrosive coatings.

This strip is supplied by a private firm, "Schöne", (Gross-Rehsdorf); it also supplied special types of ready insulation for tubes, cables and other purposes as well as plastic anticorrosive self-adhesive strip (20-130 mm wide in coils of 10-20 mm length) which contains no phenols and adheres well to the coating material. The strip is used for wrapping steel tubes in the field by hand, for the repair of damaged coating, for protecting tubes laid through walls, and for other purposes.

The firm also produces a dense nonadhesive tape on the tissue base, which is covered with a 3 mm layer of high-quality substance. It is used for repairing damaged coatings on steel tubes of large diameter and for additional coating of tube junctions. The firm maintains that steel pipelines covered with this coating can last for at least 50 years if cathodic protection against stray currents causing electrochemical corrosion is applied.

To prove the durability of this type of coating, the firm demonstrated, in its laboratory, specimens of the cotton strip which was kept in 10% hydrochloric acid for 22 months and still maintained its form and strength.

It should be stressed that a great deal of attention is paid abroad to the problem of protecting the tubes with anticorrosive coatings.

As a rule, all pipelines are coated very throughly and thus their service life is extended substantially. In the main, the tubes are coated with a protective layer at the tube works where it is possible to mechanize the process and to ensure a better quality of the coating than would be obtained in the field.

* * *

New Books

D. L. Maizel's and M. M. Bystrova. The Cost of Ferrous Metals, Moscow, Metallurgizdat, 1958, 187 pages.

The book contains an account of the experience of leading establishments with respect to exposing potential productivity reserves, a discussion of ways of reducing production costs, an account of the system of casting pig-iron, steel and rolled products, estimating methods of planning, accounting and analyzing of costs.

The book is intended for workers and foremen in leading metallurgical trades and may be useful for engineers and technologists.

The first two chapters contain an account of costs as a source of internal industrial reserves (the main conditions for reducing production costs, the relationship between the costs of production,the prices of the product and the profitable functioning of industrial establishments) a classification and a description of production expenses in ferrous metallurgy,i.e., data on the system of expenditure in the metallurgical industry as compared with other industrial branches and provisional data on the percentage of fixed costs in processing steel.

The third chapter tells the reader about the general principles of calculating and estimating the production of metallurgical works; the standard nomenclature of individual items, the method of evaluating the actual cost of production and the procedure of presenting process calculations are given.

The cost of pig iron, steel and rolled product is discussed in Chapters IV, V, and VI; the procedure for presenting calculations for each branch of production is given.

Chapter VIII is devoted to a short discussion of the content and the method of analysis of production costs. Analytical tables are given for comparing various factors affecting the deviations in the production costs from the planned figures.

The basic principles of internal accounting within the iron and steel works are discussed in Chapter IX. The problems of administrative and financial incentives aimed at the rational use of production means, the fulfillment of the production plans within the limits determined by the number of employees and the funds earmarked for wages, the utilization of the internal potentialities of the works and the reduction in production costs, as well as incentives (allowances and additional payment) in accounting between individual shops are discussed. Every metallurgist will find this book useful.

G. S. Romashkovtsev. Controller of the Department of Technical Control at the Open-Hearth Shop. Moscow, Metallurgizdat, 1959, 214 pages.

The introduction to the book contains general information on the departments of technical control at iron and steel works: the task of the OTK (Department of Technical Control), its structure, main inspection points,etc. Then the author discussed the work of the OTK in the internal inspection and acceptance section at the open-hearth furnace shop. The rules relating to the acceptance of materials, the requirements with regard to raw materials for open-hearth shops, the methods of inspecting the refractories, the documentation and sampling of materials are described in detail.

The second chapter of the book contains a description of the technical control at the charge yard of the open-hearth shop. The rules relating to the storage of charge materials, the control of loading and unloading the charge, the GOST and Technical Specifications for soil, scrap, and ferroalloys and the preparation of reports at the charge yard are given. The third chapter is devoted to the technical control in the furnace bay of the open-hearth shop, and the fourth to the control of steel-pouring process. Third chapter contains a short account of the technology of melting and pouring the open-hearth steel and methods of controlling these processes. The main types of steel defects, the causes of defects and their prevention are described in detail.

The book is intended as a textbook for technical schools and may be useful for controllers of steelmaking shops.

N. V. Litovchenko and B. B. Diomidov. Increasing the Output of Steel-Rolling Mills. Moscow, Metallurgizdat, 1958, 179 pages.

The book contains an account of the operational experience of steel rolling mills at one of the iron and steel works where considerable technical improvements have been carried out in recent years.

The operation of blooming and billet mills is considered in the first chapter of the book. A detailed description of the effect of ingot weight and the temperature before rolling on the output of the blooming mill is presented; systems of drafts and new techniques of outstanding operators are presented. The roll design and the installation of additional stands at blooming mills, with the object of increasing the drafts in the last passes and increasing the output by 15-20%, are considered. The economics of the installation of billet and continuous-billet mills behind the blooming mill are discussed.

In the second chapter of the book the technology of rolling billet at section mills is considered in detail; the specialization of mills depending on the sections rolled is described; the equipment, roll design, and technology of rolling at heavy-section, medium-section, continuous and light-section mills are described; new methods of rolling and roll changing, and the use of repeaters on both sides of the stands are also discussed.

The third chapter of the book is devoted to the technology of rolling on multistrand, continuous, wire mills; ways of increasing the output of these mills are indicated. In addition, changes in the character of deformation of oval sections in the finishing round pass are described and the rolling of deformed concrete-reinforcing bars is considered.

In the fourth and last section of the book the automation of rolling mills and of the main and auxiliary equipment is described. This automation would ensure economic plant operation, effective use of equipment and maximum output.

The book is well illustrated with sketches, drawings and diagrams. It is intended for technical personnel and may also be useful to industrial workers and metallurgy students at universities and technical schools

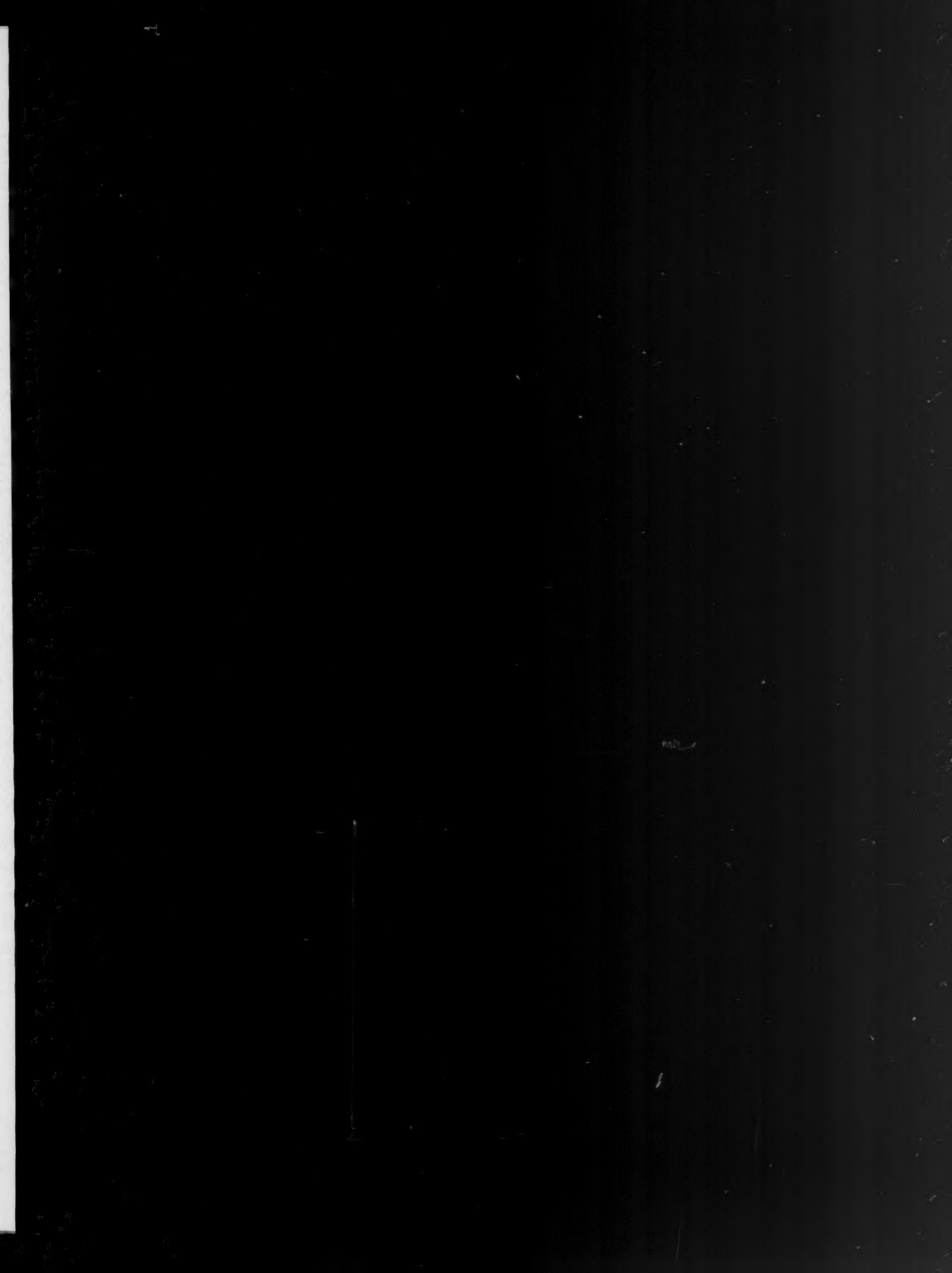
Refractories in the Iron and Steel Industry. Collection of Articles. Moscow, Metallurgizdat, 1958, 277 pages, price 9r.85k.

In this collection, the main trends in the development of the refractory industry are considered. The articles, written by outstanding scientists and technologists, give an account of the production of new high-duty heat-resistant and heat-insulating materials. A few articles are devoted to the use of refractory materials in metallurgical furnaces, ladles, and other equipment. The problems of producing highly heat-resistant mortar and concrete are discussed.

The book may be useful to the technical personnel of the iron and steel industry.

If the book is not available in the Knigotorg shops, orders can be sent to Moscow G-34, 2nd Obydenskii per. 14, Sales Department, Metallurgizdat.

SIGNIFICANCE OF ABBREVIATIONS MOST FREQUENTLY ENCOUNTERED IN SOVIET PERIODICALS

FIAN	Phys. Inst. Acad. Sci. USSR.
GDI	Water Power Inst.
GITI	State Sci.-Tech. Press
GITTL	State Tech. and Theor. Lit. Press
GONTI	State United Sci.-Tech. Press
Gosénergoizdat	State Power Engr. Press
Goskhimizdat	State Chem. Press
GOST	All-Union State Standard
GTTI	State Tech. and Theor. Lit. Press
IL	Foreign Lit. Press
ISN (Izd. Sov. Nauk)	Soviet Science Press
Izd. AN SSSR	Acad. Sci. USSR Press
Izd. MGU	Moscow State Univ. Press
LÉIIZhT	Leningrad Power Inst. of Railroad Engineering
LÉT	Leningrad Elec. Engr. School
LÉTI	Leningrad Electrotechnical Inst.
LÉTIIZhT	Leningrad Electrical Engineering Research Inst. of Railroad Engr.
Mashgiz	State Sci.-Tech. Press for Machine Construction Lit.
MÉP	Ministry of Electrotechnical Industry
MÉS	Ministry of Electrical Power Plants
MÉSÉP	Ministry of Electrical Power Plants and the Electrical Industry
MGU	Moscow State Univ.
MKhTi	Moscow Inst. Chem. Tech.
MOPI	Moscow Regional Pedagogical Inst.
MSP	Ministry of Industrial Construction
NII ZVUKSZAPIOI	Scientific Research Inst. of Sound Recording
NIKFI	Sci. Inst. of Modern Motion Picture Photography
ONTI	United Sci.-Tech. Press
OTI	Division of Technical Information
OTN	Div. Tech. Sci.
Stroiizdat	Construction Press
TOÉ	Association of Power Engineers
TsKTI	Central Research Inst. for Boilers and Turbines
TsNIÉL	Central Scientific Research Elec. Engr. Lab.
TsNIÉL-MÉS	Central Scientific Research Elec. Engr. Lab.-Ministry of Electric Power Plants
TsVTI	Central Office of Economic Information
UF	Ural Branch
VIÉSKh	All-Union Inst. of Rural Elec. Power Stations
VNIIM	All-Union Scientific Research Inst. of Meteorology
VNIIZhDT	All-Union Scientific Research Inst. of Railroad Engineering
VTI	All-Union Thermotech. Inst.
VZÉI	All-Union Power Correspondence Inst.

Note: Abbreviations not on this list and not explained in the translation have been transliterated, no further information about their significance being available to us - Publisher.